Developing and Testing a Framework for Alternative Ownership, Tenure and Governance Strategies for the Proposed Detroit-Windsor River Crossing

(Phase I Progress Report)

(DRAFT)

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CHAPTER 1
INTRODUCTION

BACKGROUND

Transportation infrastructures are integral parts of a nation's network connectivity. Large-scale transportation projects represent major investments devoted to the construction, operation, and maintenance of facilities over an extended period. Typically, these investments are irreversible in nature and require long-term commitment by the public at large relative to utilization, maintenance, and operation. Examples are mass-transit systems, freeway corridors, subways, crossings in the form of bridges and tunnels, high occupancy vehicle (HOV) lanes, and toll roads. A National Transportation Statistics report suggests that total gross transportation *investment* by the federal, state and local governments reached $80 billion in the US in the fiscal year 2003 (BTS 2008). Similarly *expenditures* in operating, maintaining and administering the nation's transportation facilities are over $200 billion annually. Projected federal, state and local highway *revenues* are insufficient to meet estimates of future highway requirements (USDOT 2006). Lack of capital funds to meet the infrastructure needs of the country may result in increased private participation in such projects (Roth 1996). The investment, expenditures, and revenue from 1991 to 2003 measured in year 2000 dollars is presented in Fig. 1.1 – Fig. 1.3.

The potential of transportation infrastructure projects to produce economic benefits has become an increasingly important factor in the investment decision process. Some of these large investments may also involve the private enterprise in the construction, operation and maintenance process along with the federal, state and local governments.

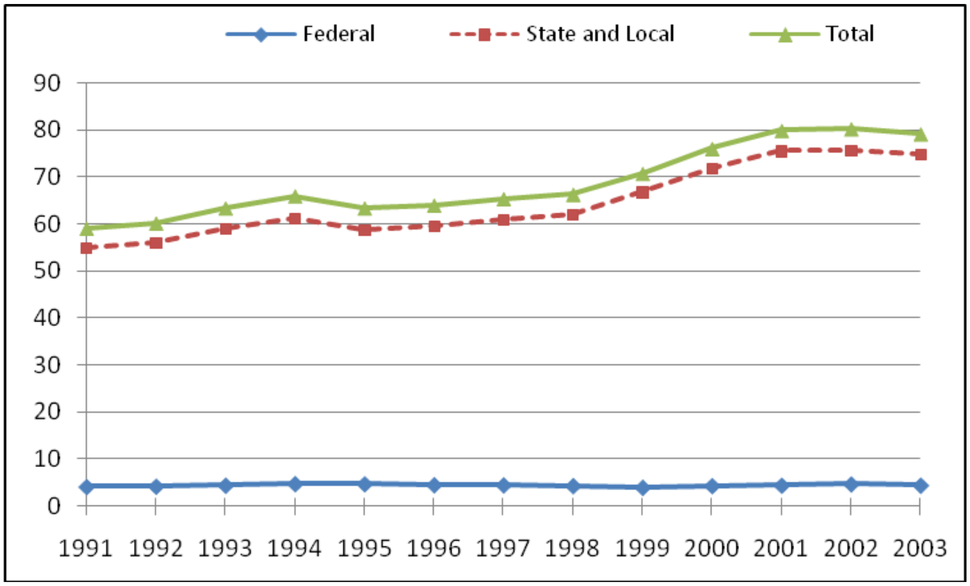

Figure 1.1: Gross investment in transportation infrastructure by level of government. (Primarily in the form of new construction)
(Source: Transportation Statistics Annual Report: 2008, USDOT)

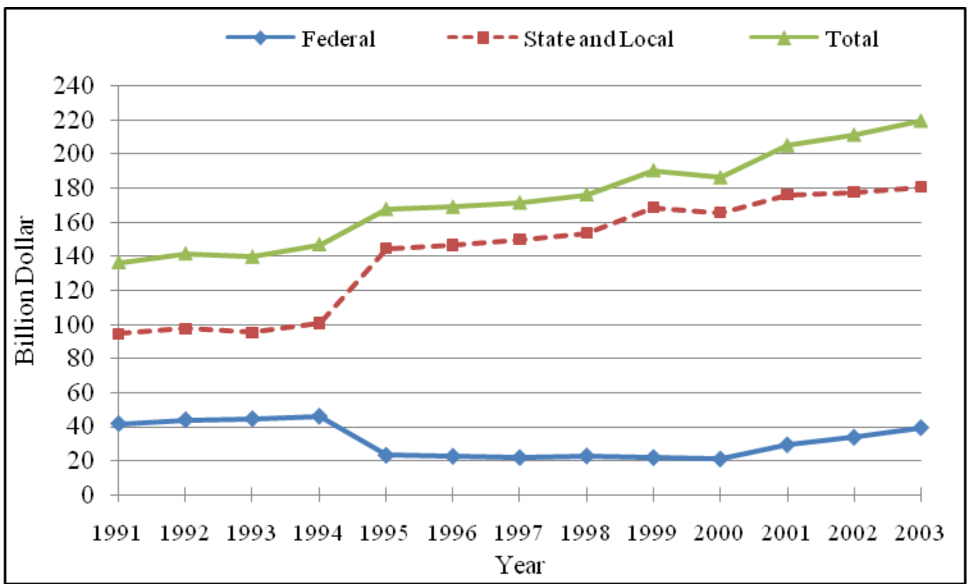

Figure 1.2: Federal, State, and Local Government Transportation Expenditures. (Primarily in the form of operation, maintenance and administration)
(Source: Transportation Statistics Annual Report: 2008, USDOT)

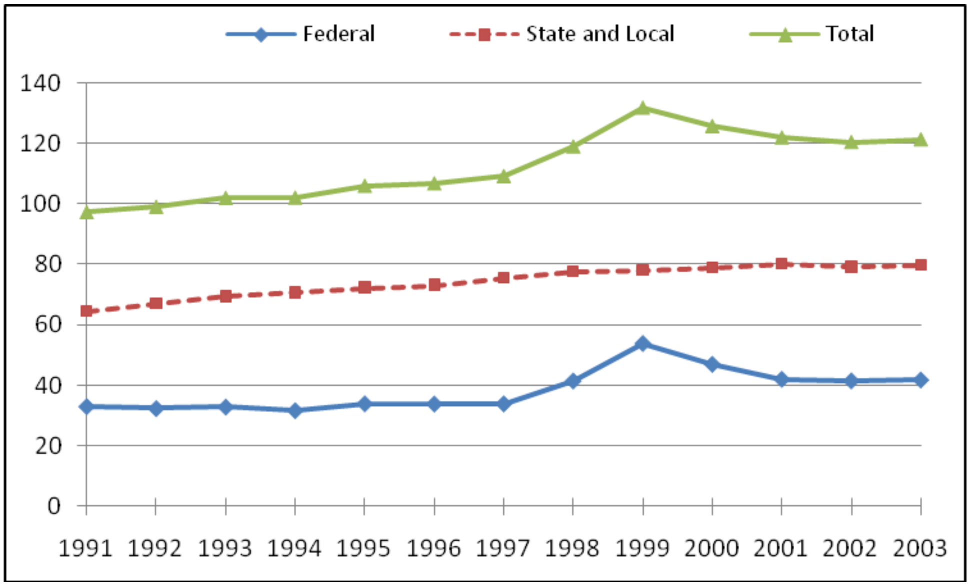

Figure 1.3: Federal, State and Local Governments Revenues
(Source: Transportation Statistics Annual Report: 2008, USDOT)

Experienced investors in transportation projects are aware that such projects typically involve huge initial costs, take long to complete and are reliant on future cash flows to meet financial obligations and to provide reasonable returns. In general, economic analysis techniques are used to compute future returns. Most of these techniques fall into two categories, i.e. predictive (*ex ante*[1]) or evaluative (*ex post*[2]) (Boardman, Greenberg et al. 2001). Predictive analysis is used to forecast the likely economic impacts of a proposed investment, whereas evaluative techniques are used to gauge the effect of the investment after it has been implemented (Systematics 1998).

Traditional economic analysis techniques are based upon the assumption of future cash flows that are fully deterministic in nature. Thus, these are not designed to account for risk and

[1] Ex ante is performed when the decision is made about whether or not to proceed with the project before its implementation.

[2] Ex post is performed after all the impacts of the implemented project is realized.

uncertainty involved in the assessment of future returns. In reality, many of these infrastructure projects are associated with significant uncertainties stemming from lack of knowledge about future cost streams. Revenue generation is also characterized by demand uncertainty. In emerging markets, macroeconomic, legal, institutional and regulatory concerns may add a level of uncertainty that can add complexities and introduce greater levels of risk. As explained later in the report, the term "risk" refers to situations where the decision maker can assign mathematical probabilities to the randomness relative to future outcomes. In contrast, the term uncertainty refers to situation when this randomness cannot be expressed in terms of mathematical probabilities (Knight 1921). Transportation decisions have not typically considered risks and uncertainties in investment analysis. Current transportation literature does not indicate the availability of a comprehensive methodology in dealing with risks and uncertainties, though significant research been conducted in economics, industrial engineering and financial management.

The trillion dollar transportation infrastructure in the US has been financed primarily by public dollars through various forms of user taxes (Garber and Hoel 2002). The Highway Trust Fund created by Congress in the mid-1950s was used to build the interstate highway system (formally the Defense Highway System) that serves as the backbone of the nation's transportation network today and that has provided much of the stimulus for regional economic growth. Since the completion of the interstate system in the early 1990s, Congress has taken a number of landmark legislative actions to support the transportation infrastructure in the US. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the 1998 Transportation Equity Act for the 21st Century (TEA-21), and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) of 2005 will have provided over

$700 billion of support for the transportation infrastructure of the country for the period 1992 through 2010. The intent of these acts is to develop and maintain a multimodal transportation system that is economically efficient and environmentally sound, and that will enable the nation to compete in global economy.

Historically, the highway infrastructure in the US has been built and maintained by public funds, with a few exceptions. Factors such as improved mobility, reduced congestion, and higher safety, along with economic benefits have been used to justify these investments. Tollways and turnpikes, regardless of tenure, constitute a small fraction of US highways, and are somewhat of an exception to this rule. Typically, these facilities are financed by long-term bonds, and the revenue generated by the facilities is used to pay for the investment. Only limited private funding has been used in the U.S. for roadway infrastructure. Private participation is, however, more common in other modes of transportation, particularly rail, air and transit prior to 1950s. Programs for these modes have been characterized by sharing of costs and revenues by the private and the public enterprise.

PROBLEM STATEMENT

The purpose of the above discussion is to provide a background of this study focusing on a proposed international crossing across the Detroit river in the Midwest, connecting the cities of Detroit, USA and Windsor, Canada. The Central Business Districts (CBDs) of the cities of Detroit and Windsor are currently connected by a bridge and a tunnel across the Detroit River, both built during the late 1920s. The Ambassador Bridge is a privately owned four-lane suspension structure, while the Detroit-Windsor tunnel is a two-lane facility with height restriction, jointly owned by the two cities and operated by a private corporation. These two facilities constitute a major component of the vital trade-corridor between the US and Canada in the Midwest. Two other facilities carry freight between Michigan and Ontario. These are: a rail tunnel under the Detroit river at Detroit and the Blue Water Bridge over the St. Clair river (100 km north of Detroit), which connects Port Huron, USA and Sarnia, Canada

The United States and Canada share the largest trading relationship in the world. Currently $200 billion of surface trade passes annually between Southwestern Ontario and Southeastern Michigan, a figure expected to reach $300 billion by the year 2030. More than 50% of this traffic crosses the Detroit River by truck (MDOT 2003). This large trade volume has a significant positive effect on the local, regional and national economies, through cross-border employment, opportunities. The vehicular crossings between Southwest Ontario and Southeast Michigan are the busiest of all Canada-US border crossings, and the Ambassador Bridge ranks the highest in commercial vehicles among all US border crossings (MDOT 2003).

The Ambassador Bridge (a four lane facility) , on an average day, carries approximately 26,500 passenger-cars and 12,000 commercial vehicles and these figures are projected to increase by more than 40% and 100% respectively by the year 2030 (MDOT 2003). The corresponding figures for the Detroit-Windsor Tunnel (a two lane facility) are 25,000 and 700 with projected increases of 100% and 30% respectively by 2030 (MDOT 2003). The long-range prediction of the trade volume clearly indicates that the two existing Detroit River vehicular crossings (and any additional crossing that may be opened in the future) will have a major part in the overall economic picture of the Southeast Michigan and Southwest Ontario region, not to mention the cities of Detroit and Windsor. Traffic volume trends of three crossings is presented in Figure 1.4 – 1.6.

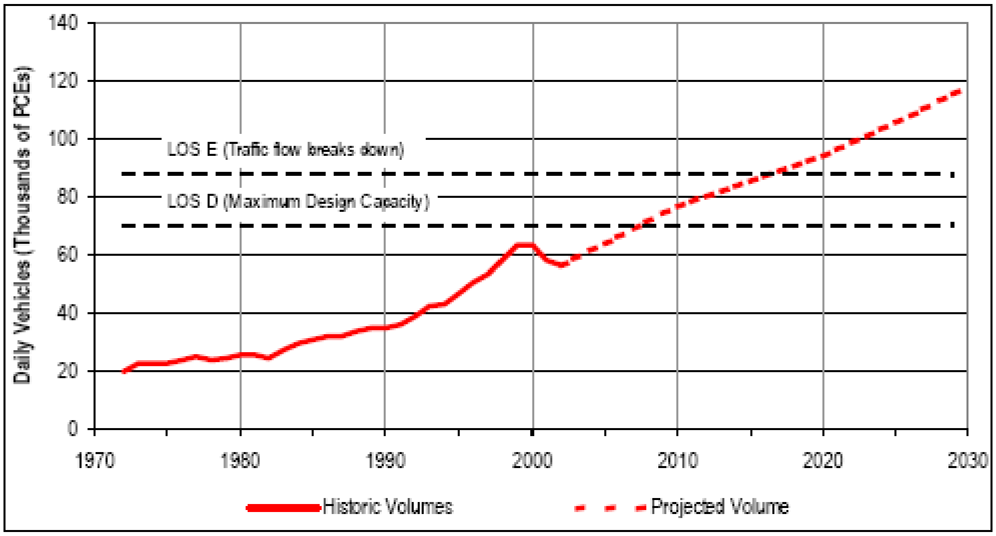

Figure 1.4: Traffic volume trend of Ambassador Bridge (Source: Final Environmental Impact Statement Report of the Detroit River International Crossing Study, March 2008)

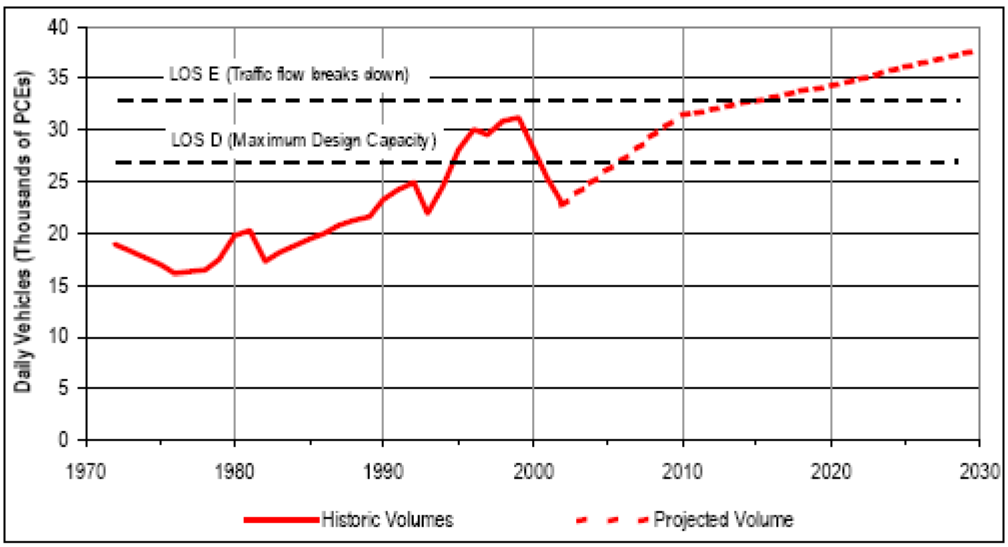

Figure 1.5: Traffic volume trend of Detroit-Windsor Tunnel (Source: Final Environmental Impact Statement Report of the Detroit River International Crossing Study, March 2008)

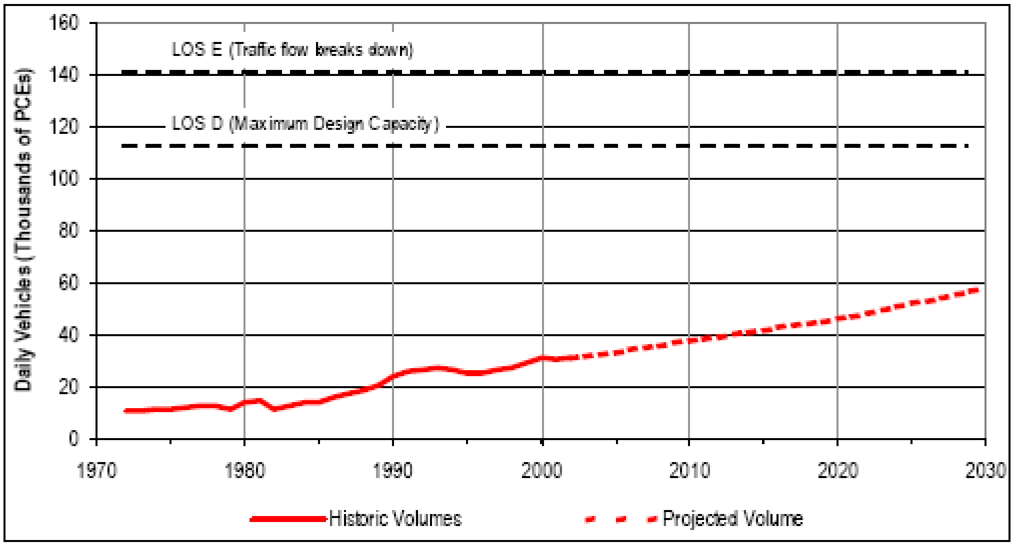

Figure 1.6: Traffic volume trend of Detroit-Windsor Tunnel (Source: Final Environmental Impact Statement Report of the Detroit River International Crossing Study, March 2008)

A number of recently completed and ongoing studies sponsored by the Michigan Department of Transportation (MDOT) and the Ontario Ministry of Transportation (OMT) consider various issues related to a new Detroit River crossing. The Canada–US–Ontario–Michigan Transportation Partnership Study (Partnership Study) attempted to develop long-term strategies to provide for safe and efficient movement of people and goods between Michigan and Ontario (FHWA, 2003). Even though the current capacities of the Ambassador Bridge and the Detroit-Windsor tunnel adequately serve the traffic needs during most hours, on specific days during peak periods the systems do run at full capacity. Considering long-term traffic growth and the overall importance of the Detroit River crossings on the regional economy, the need for a third crossing seems immensely justified. A second study, Evaluation of Alternatives from US and Canadian Sides of the Border–explored various alternatives for the proposed new crossing and is expected to recommend the most-desired alternative, based upon a set of comprehensive Environmental Impact Statements (FHWA, 2003). This study originally identified a total of 15 alternatives, depicting different bridge structures, plaza locations and connecting routes, that have been narrowed down to three, based upon context-sensitive design considerations, expert opinions, and technical viewpoint. The three alternatives are:

1. X-10 (A), (Dearborn-I75- Shortest route length, least capital intensive)
2. X-10 (B), (Springwells –I75)
3. X-11 (C), (Dragoon-I75- Highest route length , most capital intensive)

Figure 1.7 : Proposed alternatives for the bridge crossing (Source: Final Environmental Impact Statement Report of the Detroit River International Crossing Study, March 2008)

This study is built upon the premise that a new crossing will be built in the near future. The central question that our research will address is *"Should the new crossing be owned and operated by a (yet to be named) public agency, so that the taxpayers can benefit from the significant revenues likely to be collected over the life of the project? Or, should the ownership and operating rights be left to the private enterprise, thereby protecting the public at large from the risks associated with this investment?"* Limited research shows that there is a strong interest on the part of the private enterprise on either side of the border, to own and operate such a new crossing, if proposed. The development of a framework to analyze the fiscal, institutional and legal issues associated with the ownership of the new crossing (Public vs. Private vs. Public Private Partnership) is the problem investigated in this study. Thus, the problem addressed relates to the issues of ownership, tenure, and governance of the proposed river crossing connecting the cities of Detroit and Windsor providing for multibillion dollar trade opportunities between the US and Canada.

A brief explanation of the terms public, private and joint ownership is explained below.

- Public Ownership: Public ownership is desirable when strong gains are possible, so that tax-payers can be the ultimate beneficiaries of the project. However, both the capital and operating cost remain the responsibility of the public operator. Hence, for projects lasting over an extended period, estimates of future costs and revenues should be adjusted to effect risks and uncertainties.

- Private Ownership: Private ownership presents both advantages and disadvantages to the tax-payer. The tax-payer is not a recipient of any monetary benefits, nor is the tax-payer responsible for the capital, operating and maintenance costs. The private sector that makes the investment is logically entitled to all future revenues. Because the facility is essentially for public use (to improve mobility for public at large), most experts feel that there should be some degree of regulatory control over the management and governance of the facility by the public entity, even though ownership is fully private.

- Joint Ownership: Often used interchangeably with the term Public Private Partnership (PPP), joint ownership concept has become increasingly popular in Europe, Australia and Asia, as it allows part or the whole of the capital funds from private resources in exchange of future revenues. Even though these two terms are often used interchangeably, they may not necessarily mean the same. The term joint ownership refers to the ownership of the facility, while PPP refers to some type of partnership that may or may not involve ownership. It is possible for example; for two agencies to be partners on a given project, while ownership may remain with one agency or a third agency.

Many forms of Joint ownership are feasible (depending upon the exact share of capital and operating cost between the principal and the private partners, and the governance structure mutually agreed upon). A "Build Own Operate and Transfer" (BOOT) concept, under the general umbrella of Joint ownership, is being used in a number of countries. Variations of the BOOT concept used in different countries and in different projects is discussed in the next chapter (Merna and Njiru 1998).

> "A project based on the granting of a concession by a Principal, usually a government, to the Promoter, sometimes known as the Concessionaire, who is responsible for the construction, financing, operation and maintenance of a facility over the period of concession before finally transferring the facility, at no cost to the Principal, as fully operational facility. During the concession period, the Promoter owns and operates the facility and collects revenues to repay the financing and investment costs, maintain and operate the facility and make a margin of profit."

A concession agreement defines the roles and responsibilities of the participating agencies, particularly the Principal (typically the Governmental agency that is ultimately responsible to the public for the project operation), the promoter (the private agency that assumes the overall responsibility on a temporary basis), and the support agencies. BOOT projects are essentially turnkey contracts financed by the contractor, with extended operation and maintenance periods. Note BOOT concept specifies that project is to be transferred to the principal at the end of the concession period "at no cost to the principal, as a fully operational facility." Thus, if the project is planned properly, the Principal or the Government agency has nothing to lose, as it essentially inherits a free facility that is "fully operational," at the end of the concession period. It is, however, important for the Governmental agency to ensure that the facility continues to generate revenue at the end of the concession period, without a major investment of resources. The private entity, on the other hand, can take advantage of an investment opportunity, and generate a healthy return over the concession period.

PROJECT OBJECTIVES

Because of the current financial situation of the State of Michigan and because of the risks associated with such an investment, questions have been raised about the wisdom of the tax-payer investing over one billion on a project, where private funding appears available. This report presents an analytic framework that can explore the merits and demerits associated with public and/or private ownership of the crossing, where potentials for cost recovery through revenues generated appear to be high at one end but fraught with risk at the other. The framework will also explore various forms of joint ownership of the proposed crossing structure between the public and private enterprise. The testing of the framework is currently underway in Phase II.

The analytic framework will be developed based upon the principles of investment decision under uncertainty. The framework should be sensitive to the issues of tangible and intangible effects of the investment upon the owner, the users of this facility, as well as the communities that are likely to be affected. Additionally, there is a considerable degree of uncertainty associated with expenditures and returns associated with the proposed infrastructure. The proposed framework will explore means of incorporating uncertainties associated with such investment decisions. Thus, the objectives of the study are as follows:

1. Identify Different Strategies ranging from public to private to various forums of joint OTG scenarios.
2. Identify Barriers and Opportunities Associated with the OTG Scenarios.
3. Develop an Analytic Framework that can be used to test different OTG scenarios.
4. Identify Measures of Effectiveness (MOE's) to evaluate OTG scenarios.

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CHAPTER 2
LITERATURE REVIEW

INTRODUCTION

Transportation infrastructure investments typically undertaken by the public sector, has recently attracted private entities, thereby forming a joint participation commonly referred to as Public Private Partnership (PPP). Financing techniques are developed to provide various forms of ownership, tenure and governance (OTG) strategies. There are a number of reasons for the growing trend of private participation in public projects. These include, the scarcity of fiscal resources at the public sector level, the perception that the private sector is more efficient in managing (construct, operate, and maintain) large projects, and sharing risks and uncertainties with the private sector, thereby reducing exposure levels to financial losses for both entities.

Most investment decisions share three important characteristics in varying degrees. First, the investment is partially or completely irreversible in that the funds invested are completely "sunk" in the project. Thus the agency or agencies responsible for managing the project, must be fully committed to the project once the investment is made. Second, there are uncertainties over the future outcome from the investment. One way to address this is to assess the probabilities of the alternative outcomes that can mean greater or smaller profit (or loss) for the investment. The third characteristic is related to timing of the investment. With proper planning, investment decisions can be postponed until credible information about future outcomes may be available. These three characteristics interact to determine the optimal decision of investors (Weston and Brigham 1976).

Typically risks result from uncertainties. Risk involves situations where the probability of a particular outcome is known, while uncertainty exits when the probability is not known

(Choobineh and Behrens 1992). Risk is the consequence of taking an action in the presence of uncertainty, while uncertainty is the manifestation of unknown consequences of change (Sarper 1993). Risk exists in economic analysis because each input element may have a number of possible outcomes, thus relating risk to uncertainty of outcome. Uncertainty analysis is performed as part of the decision-making process to enable the decision maker to assess the degree of confidence in the decision and associated project risks (Winston 2000; Borgonovo, Apostolakis et al. 2003). The framework presented in this study attempts to incorporate the effect of uncertainties associated with future outcomes.

Though the terms risk and uncertainty are often used interchangeably, their implication from an investment viewpoint is somewhat different. There are several definitions of risk and uncertainty in the literature, as these terms are associated with investment decisions in various fields of engineering, business and management. *Risk* is quantifiable with a measurable probability of deserving / not deserving certain returns. *Uncertainty* is associated with lack of any information / knowledge about future outcomes (Ayyub 2003). Various methods are used to measure risk and uncertainty. This chapter focuses on a review of the state of the art on four major aspects of PPP focusing different OTG concepts: (1) Joint ownership, (2) Uncertainty, (3) Risk, and (4) OTG strategy.

JOINT OWNERSHIP

Traditionally transportation infrastructures are designed, planned, financed, and administered by the public entity at the federal, state, and local levels. Such infrastructures are typically supported by ‘borrowed funds’, and the revenue generated from toll/fare is used to pay off the debt. While the tangible revenue generated is from toll / fare, the revenue predicted for future years in the form of toll is not deterministic in nature, involving greater uncertainty. With scarce financial resources of public entity, and uncertain returns of future revenues, there is a growing trend world-wide of PPP in building and managing infrastructure projects today.

> *"PPP is a technique to attract private capital in a public project that would otherwise be beyond the scope of the public entity"*. (Yescombe 2007)

The PPP approach has been successfully deployed to infrastructure (Geltner and Moavenzadeh 1987; Nijkamp and Rienstra 1995; Fortner 2001), health industry (Victoria 2001), maintenance projects (USDOT 2006). The approach is gaining popularity in the US and around the world. Some examples in the US are: the SR-125 project in San Diego County California (Garin 1995), the city of Cleveland for the long term sustainable development (Goss 2002), a road rehabilitation and expansion project in Orange County California (Henk 1998), a light-rail transit system in Portland, Oregon (Landers 2002), a 10 mile express lane on existing State Route 91, California (Levy 1996), a 14 mile toll road extension in Leesburg, Virginia (Euritt, University of Texas at et al. 1994), Las Vegas Monorail (USDOT 2006). Other examples around the world are; a large city link toll road project in Melbourne, Australia (Alonso-Conde, Brown et al. 2007), the Mexico City-Guadalajara project, a toll road in Mexico (Huang 1995), the Keping toll road in Malaysia (Walker and Smith 1995), highway in Pearl Delta River region China (Yang and Meng 2000), tunnel projects in Hong Kong (Zhang and Kumaraswamy 2001), and a series of toll bridge projects in India (Malini 1999).

Forms of PPP

There are number of ways a private agency can be involved in a successful PPP venture. A PPP is characterized by the degree to which the public and private sectors share the risks, responsibilities, obligations, and benefits of project. Some of the structural options available for the PPP scheme in road infrastructure include the following models (Huang 1995; Hakim, Seidenstat et al. 1996; Sanchez 1998; Subprasom 2004; Alvis 2006; NCPPP 2008).

Table 2.1: PPP Forms

Sl	PPP Form	Full Form
1	BOT	Build Operate Transfer
2	BTO	Build Transfer Operate
3	BBO	Buy Build Operate
4	BC	Build Construct
5	BT	Build Transfer
6	BLO	Build Lease Operate
7	BLT	Build Lease Transfer
8	BOOT	Build Own Operate Transfer
9	BOOS	Build Own Operate Sale
10	BOLT	Build Own Lease Transfer
11	BOO	Build Own Operate
12	BOST	Build Own Subsidize Transfer
13	DB*	Design Build
14	DBM*	Design Build Maintain
15	DBO*	Design Build Operate
16	DF	Design Finance
17	DBFO*	Design Build Finance Operate
18	DCMF	Design Construct Manage Finance
19	LDO	Lease Develop Operate
20	LP*	Lease / Purchase
21	SL	Sale / Leaseback
22	LRT	Lease Rehabilitate Transfer
23	LOT*	Lease Operate Transfer
24	OM*	Operate Maintain
25	OMM	Operate Manage Maintain

26	MOT	Modernize Own/Operate Transfer
27	OP	Outright Privatization
28	ROT	Rehabilitate Operate Transfer
29	ROO	Rehabilitate Own Operate
30	TOR	Transfer of Operating Rights
31	ITF	Inside the Fence Projects
32	TURNKEY	
33	EUL	Enhanced Used Learning

Note: * FHWA common forms of PPP

1. **Build-Operate-Transfer (BOT)**

The private entity builds a facility as per the specifications agreed to by the public entity, operates the facility for a specified time period under a contract or franchise agreement with the agency, and then transfers the facility to the public agency at the end of the specified period of time.

In most cases, the private partner will also provide some, or all, of the financing for the facility, so the length of the contract (commonly known as concession period) must be sufficient to enable the private partner to realize a reasonable return on its investment through user charges. At the end of the concession period, the public entity can assume the operating responsibility for the facility.

2. **Build-Transfer-Operate (BTO)**

In BTO structure, the private entity transfers the project to the public entity after completion of construction for a specified payment (as per contract). Following the construction, the private entity operates the facility and the public entity pays for the operation of the facility.

3. **Buy-Build-Operate (BBO)**

In BBO structure, the facility is transferred to the private entity, usually under a contract for the upgrading/rehabilitation/expansion and operation of the facility for a specified period of time. Little or no public interaction is involved during the life of the contract.

4. **Build-Contract (BC)**

In BC structure, the public entity only bids out a construction contract. The contractor selected builds the project as per the specifications of the construction contract, and upon technical completion[3], the constructed project is transferred to the public entity. Such form of PPP utilizes the expertise of the private entity such as building proficiency, competitive bids, effective construction, thereby reducing the exposure level of the public entity to risk.

5. **Build-Transfer (BT)**

In BT structure, the private entity is responsible for construction of the facility and transferring the project to the public entity for operation and maintenance. The public entity either uses the toll revenue to pay off or involves the private entity in the bidding process of another project to help retrieve the investment capital with a reasonable profit.

6. **Build-Lease-Operate (BLO)**

In BLO structure, the private entity builds the facility and then leases the facility for operation (either to public / another private entity). In this case, the private entity takes the construction risk (also takes a step beyond BC). This structure of PPP allows the public sector to transfer the risk on construction, operation and financing to the private sector.

7. **Build-Lease-Transfer (BLT)**

[3] If the construction is not performed adequately or on time, the public entity only pays at the end of construction, commonly referred as technical completion.

BLT is similar to the BLO structure, with the provision that the private entity takes the risk on construction but not necessarily on operation.

8. Build-Own-Operate-Transfer (BOOT)

In BOOT structure, the private entity builds, owns, and operates the facility. Private operation terminates at the end of concession period. The private entity receives revenues from the project (example: toll road) during the concession period. Unlike BOT, the BOOT structure allows the private agency to own the facility till the end of the concession period. The basic difference between BOT and BOOT is the ownership. The private entity can upgrade the facility to generate additional revenue (which is not the case in a BOT structure).

9. Build-Own-Operate-Sell (BOOS)

In BOOS structure, the project is built, owned, and operated by the private entity before it is sold back to the public entity at a specified price (considered to the worth of the facility at the time of sale). This structure allows the private entity to operate the facility to generate revenues and to sell the un-depreciated investment back to the public entity at a specific time point.

10. Build-Operate-Lease-Transfer (BOLT)

In BOLT structure, the private entity builds and operates the facility for a specified period of time, and at the end of the period leases it back to the public entity. The public entity takes over the facility and pays periodical amounts to the private entity till end of the concession period before permanently owning it.

11. Build-Own-Operate (BOO)

In BOO structure, the project is built, owned, and operated by the private entity. The public entity awards the private entity rights to use the assets (example land for toll road) and build the facility. The BOO structure is not intended to be transferred back to the public entity; although maintenance of the facility is a requirement which the public entity makes an order to the private entity.

12. Build-Own-Subsidize-Transfer (BOST)

In BOST structure, the private entity builds, and operates the facility for a specified period of time. It shares the operation and maintenance with the public entity before transferring the facility. Because of insufficient resources at its disposal the private entity shares few fiscal responsibilities with the public entity. The advantage to the public entity is the reduced risk in capital investment in construction.

13. Design-Build (DB)

In DB structure, the private entity provides both design and construction of a project for the public agency. This type of PPP structure can reduce time, save capital, provide stability and reduce project risk to the public entity. It also reduces conflict by having a single entity responsible to the public owner for the design and construction. The public entity owns the facility and has the responsibility for the operation and maintenance of the facility for rest of the service life.

14. Design-Build-Maintain (DBM)

DBM structure is similar to DB with the additional stipulation of the maintenance of the facility by the private entity for some period of time. The benefits are similar to the DB with maintenance risk being allocated to the private entity. The public sector partner owns and operates the facility.

15. Design-Build-Operate (DBO)

The DBO structure is an integrated partnership that provides the private entity the responsibilities of Design-Build procurements with operations. The DBO approach facilitates private-sector financing of public projects supported by user fees generated during the operations phase.

16. Develop-Finance (DF)

In DF structure, the private entity finances the construction of the public facility in exchange for the right to build residential, commercial, and/or industrial facilities at/near the facility. The private entity contributes capital and may operate the facility under the oversight of the government. The developer gains the right to use the facility and may receive future income from end users.

17. Design-Build-Finance-Operate (DBFO)

In DBFO structure, the private entity is responsible for the design, finance, and construction of the facility under a long term lease, and operates the facility during the assigned term. The private entity transfers the facility to the public entity at the end of the lease period.

18. Design-Construct-Manage-Finance (DCMF)

In DCMF structure, the private entity is responsible for design, construction and management of the facility. It also finances the upgrading of the facility for a specified period of time before it transfers the facility to the public entity.

19. Lease-Develop-Operate (LDO)

In LDO structure, the private entity leases or buys an existing facility from a public agency; invests its own capital to renovate, modernize, and/or expand the facility; and then operates it under a contract with the public agency. A number of different types of municipal facilities have been leased and developed by the transit industry under the LDO form of PPP.

20. Lease / Purchase (LP)

LP structure is an installment-purchase contract where, the private entity finances and builds a new facility, which it then leases to a public entity. The public entity makes scheduled lease payments to the private party, and accrues equity in the facility with each payment. At the end of the lease term, the public agency owns the facility or purchases it at the cost of any remaining unpaid balance in the lease. Depending upon the specific arrangement, the facility may be operated by either the public agency or the private developer during the term of the lease.

21. Sale / Leaseback (SL)

In SL structure, the public entity sells the facility to the private entity, and subsequently leases it back from the private entity. Both public and private entities may enter into a sale/leaseback structure for a variety of reasons. An innovative application of the technique is the sale of a public facility to a private entity for the purpose of limiting governmental liability under certain statutes. Under this arrangement, the public entity that sold the facility leases it back and continues to operate it.

22. Lease-Rehabilitate-Transfer (LRT)

In LRT structure, the private entity takes the responsibility to build/improve/rehabilitate the facility. The private entity pays lease charges to the public entity, rehabilitates the project, and then transfers the facility to the public entity after a specified time period.

23. Lease-Operate-Transfer (LOT)

In LOT structure, the private entity leases and operates the facility for a number of years before finally transferring the facility to the public entity at the end of the contract period.

24. Operations and Maintenance (OM)

In OM structure, the public entity contracts with a private partner to operate and/or maintain a specific service. Under this option, the public entity retains ownership and overall management of the public facility.

25. Operate-Maintain-Manage (OMM)

In OMM structure, the public entity contracts with a private entity to operate, maintain, and manage the facility. Under this option, the public entity retains ownership of the facility, but the private entity may invest its own capital in the upgrading of the facility. Any private investment is carefully calculated in relation to its contributions to operational efficiencies and savings over the term of the contract. Generally, the longer the contract term, the greater is the opportunity for increased private investment because of greater prospect to recoup the investment and to earn a reasonable return.

26. Modernize Own/Operate-Transfer (MOT)

In MOT structure, the private entity renovates the facility; operates it for a specific period of time and returns back the back the facility to the public entity.

27. Outright Privatization (OP)

OP structure attracts the private entity to benefit from existing public infrastructure. The application of OP is more common in the telecommunication industry, where privatization has provided a forum for delivering a revamped infrastructure from the owners to the users. Such approach allows the public entity to privatize the system via licensing and to benefit the end user.

28. Rehabilitate-Operate-Transfer (ROT)

In ROT structure, the private entity rehabilitates, operates, and transfers the project to the public entity after a specified time period. The basic difference between ROT and many other structures (such as BOT, BOOT, BTO, etc.) is the concession of an existing project as opposed to building a new project. This is more common in developed countries with aging infrastructure.

29. Rehabilitate-Own-Operate (ROO)

In ROO structure, the private entity rehabilitates, owns and operates the facility for a specific period of time. The maintenance of the facility during this period is the responsibility of the private entity (difference from MOT). The facility is returned back to the public entity at the end of the concession period.

30. Transfer of Operating Rights (TOR)

In TOR structure, the public entity transfers the right to use the existing assets of a divesting project to the private entity and enters into an agreement with the private entity to purchase the output of the project. The private entity must invest capital, repair/expand the project; and compensate the existing facility employees (public employees) if replacement or reduction of the work force of the project is required.

31. Inside-The-Fence (ITF)

ITF structure is a new form of emerging PPP, where industrial consumers require infrastructure for their operation and bid on the public facility for the overall operation. Such self-built infrastructure can be financed benefiting both the private and public entity

32. TURNKEY

In TURNKEY structure, the public entity contracts with a private entity to design and build the project in accordance with specified performance standards and criteria. The private entity commits to build the facility for a fixed price and absorbs the construction risk of meeting that price commitment. Generally, in a turnkey transaction, the private entity may use fast-track construction techniques and are not bound by traditional public sector procurement regulations.

This combination often enables the private partner to complete the facility in significantly less time and for less cost than could be accomplished under traditional construction techniques.

33. Enhanced-Use-Leasing (EUL)

The EUL concept originally developed as an asset management program in the Department of Veterans Affairs (VA), can include a variety of leasing arrangements, typical of PPP programs (e.g. lease/develop/operate, build / develop / operate). EULs enable the VA to lease VA-controlled properties to the private sector over a long-term.

Participants of PPP

PPP projects consist of various participants as explained below.

- The Public Entity: The primary participant of any transportation infrastructure project is the public entity, that may include different branches of the federal, state, and local governments. The government must be fully responsible for the project, enact legislation that permits the creation and operation of the project, provide the necessary support throughout the life of the concession. In case of default, the public entity may have to take over the project (Sanchez 1998; Yescombe 2007)
- The Private Entity: The private partner of a PPP project is generally an organization composed of one or several large corporations, lending institutions, insurers, institutional investors and other types of equity investors. They are entitled to construct, operate and maintain the facility during the concession period as per the agreement between the public and private entity. The two most important entities are the lenders and developers; who play key roles in the implementation of the project.
- The lenders*:* Private and public lenders provide debt financing for the private developers, and will normally require guarantees to assure themselves that the project will actually generate enough cash flow to service the debt. Some of the private debt sources are

commercial and investment banks, institutional investors, commercial financial companies, leasing companies, investment management companies, and money market funds (Dias Jr and Ioannou 1996). Other sources include the World Bank, the European Investment Bank (EIB), and the Export-Import Bank of the U.S.

- The developers*:* These are the entities who generate the project ideas and promote the ideas to their fruition. A number of private organizations can assume the roles of project developers, including the financial institutions, corporations, private investors, construction companies, engineering/design firms, and equipment/material suppliers (Ock 1998). The goal of private developers is to maximize personal and/or institutional objectives, usually profit, with minimum amount of risk.
- The equity investors: Equity investors provide cash for project by buying equity shares for profits. Some potential equity investors are project developers, institutional investors, investment and commercial banks, utility subsidiaries, local investors and developers, and international agencies such as the World Bank (Tiong, Yeo et al. 1992). The participation of local investors and developers as equity investors in a project is important not only for financing the project, but also on its management and operation.
- Local Partners: Some host governments require the use of local labor, contractors, etc. The participation of local members, especially if they are politically well connected, is a major advantage.
- Construction Consortiums: Because a PPP project is capital intensive and complex, it may require participating construction companies to assume some degree of the project risk.

PPP projects have both advantages and disadvantages, and are discussed below.

Advantages

- Additional funds for road construction: Private financing enables governmental agencies to raise more money for road construction than would be possible through regular public financing (OECD 1987).
- Enhanced performance: Countries with toll roads have been found to provide better quality maintenance than those with comparable free facilities (OECD 1987). The reason for this is that the typical finance arrangement for a BOT concession requires periodic inspection and maintenance reports to protect users and lenders.
- Construction cost and schedule: Private toll roads will often be built sooner and at less cost than projects financed through public agencies (Roth 1996).
- Ability to finance expansion: Private providers have access to sources of funds seeking profitable investments. These funds can be used to improve and extend the road. The public sector, on the other hand, can be subject to political constraints on expansion for a variety of reasons (Roth 1996).
- Other economic considerations: Tolls can be used as a method of congestion pricing, encouraging users to make more efficient route choices or use alternative transportation modes (OECD 1987).

Disadvantages

- Costs of toll collection: Manual toll collection causes indirect costs such as delays and increases fuel consumption, by requiring vehicles to stop or slow down at toll plazas. Besides, direct costs can absorb up to a third of total revenues (Roth 1996). The recent advances achieved in automatic vehicle identification (AVI), and electronic toll collection (ETC) will progressively make toll collection easier and less costly (OECD 1987).

- Increased traffic costs: Traffic cost can increase due to longer traveling distances. Some users may choose longer trips to avoid toll roads, resulting in increasing congestion on the parallel "free" roads (OECD 1987).
- The myth of free road: Very seldom do toll roads become free roads, even after they have been paid off. Once a road has been perceived as a secure source of income, it is difficult for governmental authorities to surrender the extra revenue.

Definitely there are advantages of PPP, but the major challenge is a realistic prediction of future revenues. For transportation infrastructure, the source of revenue is toll, which is generally proportional to the traffic demand. In a transportation network, the determination of toll and demand is not deterministic in nature. For example, higher toll rates may result in lower demand, hence lower revenue. So the determination of the appropriate toll and corresponding demand is a combination of optimization and traffic assignment problem. In the next section the determination of optimal toll under uncertain demand condition is discussed.

UNCERTAINTY

Uncertainty in investment decisions is well documented in literature, since the application is wide spread in the fields of engineering, business, and management. Examples of uncertainty in investment decisions on non-transportation fields include studies on: efficient evaluation of capital cost (Hirshleifer 1964); stock market equilibrium (Diamond 1967); private ownership stability and equilibrium (Dreze 1974); decisions from a firms viewpoint (Abel and Eberly 1997); urban land prices (Titman, Los Angeles University of et al. 1984); bank asset and liability management (Ouzsoy and Güven 1997); equilibrium prices and preferences for stock market (Kübler, Chiappori et al. 2002); developing strategies in the energy sector (Bjornstad 1996).

In general, transportation infrastructure investments are modeled under the assumption of deterministic environment, considering future cash flows to be ‘fixed’ during the planning horizon. However, this assumption may not be valid in reality, or may not be viable. There may be several uncertainties associated with the variables included in the estimation of forecasted measures of effectiveness (MOE). Uncertainty can be quantified in a probability distribution, which results from treating the inputs as random variables. These uncertainties could, therefore, result in the variation of traffic demand and thereby could adversely affect the future MOE (Subprasom 2004).

Recent literature on uncertainty in transportation infrastructure investment includes the work on highway pricing and capacity (Yang and Meng 2000); private toll roads on variable demand (Chen and Subprasom 2007); variable demand social surplus calculation for public investor (Zhang and Ge 2004); Marginal cost pricing for uncertain demand (Zhao and Kockelman 2006); for optimal link tolls for various traffic assignments (Yang 1999); network capacity (Ukkusuri and Waller 2006); optimal link tolls for traffic equilibrium (Yang and Huang 2004).

Travel Demand

Estimated return of a PPP project is heavily dependent on the forecasted travel demand. Travel demand is uncertain because it is a derived on many uncertain factors, such as economic and social development, road network condition, land use pattern, travelers' driving behavior, etc (Yang 1999; Yang and Meng 2000; Subprasom 2004; Yang and Huang 2004; Ukkusuri and Waller 2006; Zhao and Kockelman 2006).

Sources of significant uncertainty or potential error should be identified. Even though uncertainty is inevitable, it can be modeled to improve predictive quality (Associates and Systematics 2001). Travel demand model uncertainty can result from the choice of inappropriate variables and approximations, and the use of the incorrect mathematical expressions for representing the real world situation (Subprasom 2004). There could be other sources apart from travel demand that could affect the outcome of future returns, as explained below.

Travel Time

Travel time is a key determinant of the choice of mode and route in a transportation network. Therefore, variations in travel time will eventually affect in evaluation of MOE's in a PPP project. Mode-specific users will have different perspective of travel time and the process is complex for demand uncertainty (Zhao and Kockelman 2006). Trip making depends on travel time and willingness to pay. The value of time follows certain distribution and normally corresponds to socioeconomic characteristics of travelers (Yang and Zhang 2002; Subprasom 2004).

Recent work on network equilibrium models attempt to incorporate the effect of different values of time (VOT) by including user heterogeneity in route choice models. These models simulate the way users select a route from among the competing paths which are differentiated on the basis of two cost criteria: journey time and monetary cost. There are generally two lines of approaches when dealing with the tradeoffs between money and time in simulating users' responses to toll charges. A first line of approach consists of differentiating several discrete classes of users, each one with a VOT belonging to some interval ((Dafermos 1973); (Daganzo

1983)). The second line of approaches assumes a continuously distributed VOT across the users (Dial 1996; Dial 1997).

Cost estimate

The majority of the capital investment in transportation infrastructure is made through the construction cost; followed by the operation and maintenance cost. Variations in cost estimate can be caused by events that are difficult to control, such as political turmoil, labor strike, availability of materials, and delay in land delivery by the host government (Chang 1996). Maintenance-operating cost variation can unexpectedly increase due to damages of structure or equipment from some kind of natural disaster or from increasing cost of improperly installed or manufactured equipment. Construction and maintenance-operating costs exceeding original estimates may lead to cost overrun risk. It is better to model the variation in cost estimates for risk than uncertainty.

RISK

Each project embodies unique type of risks, that need to be identified and analyzed. The term risk is defined in literature in many ways. Few definitions are presented below;

- "The exposure to the chance to occurrences of events adversely or favorably affecting project objectives as a consequence of uncertainty" (Al-Bahar 1988).
- "The term risk in statistics is defined as a situation where there are two or more possible outcomes, and a probability associated with each outcome" (Newman 1983).
- Risk is an expression or possible loss over a specific period of time which may be indicated by the probability of loss in dollars or other operating units. (Hammer 1972)

- A measure of probability and severity of adverse effects. (Lowrance 1976)
- “A function of two major factors: (a) the probability that an event, or series of events of various magnitudes, will occur, and (b) the consequences of the event(s)”. (Petak and Atkisson 1982)
- “The exposure to possible economic loss or gain arising from involvement in the construction process”(CII 1988).
- "The exposure to the possibility of economic and financial loss or gain, physical damage or injury, or delay as a consequence of the uncertainty associated with pursuing a particular course of action" (Chapman 1991).
- Risk is a measure of the probability and consequence of achieving a defined project goal (Kerzner 2005).
- Risk is basically a mathematical description of the frequency and severity and the variability of the risk, summarized using a probability distribution function (PDF) (Sanchez 1998).

Risk Identification

The most important phase of a risk analysis process is the identification of risks. A risk that is not identified cannot be quantified, controlled or transferred (Construction Industry Institute (CII), 1988). In this phase, the risks that are likely to affect the project, both positively and negatively, are identified and their characteristics documented. The end product of this phase is a comprehensive description of risk events and elements. The major risk concerns of the primary parties involved in the project (host government, sponsors, financiers, and contractors) must be addressed to identify all potential risks. Some of these risk elements may include initial construction cost, construction schedule, operation and maintenance costs, through traffic, toll prices, qualification of contractors, availability and cost of financing, and regional economic stability, etc. (Sanchez 1998).

Sources of Risk

There are three generic sources of risks (1) The project, (2) Management Actions, and (3) State of the World Risk. These are explained below.

1. The Project: Risks vary with the amount of new technology, size, location, regulations, funding and other factors that arise as the amount and complexity of data increases. Despite new management techniques and tools, and advanced information technology, there may be large uncertainties that increase project cost. The following are some vital project segments that involve risk:

- New technology. The greater the amount of new technology, the larger the risk. This is not very likely to be an important risk in a toll road.
- Size and location. Larger projects and constructing in unfamiliar (or confined) locations tend to create risks beyond those initially anticipated. For example, different new circumstances must be dealt when constructing a toll road in US rather than in China, or an urban versus rural toll road.
- Regulations. If the duration of a project stretches through several years, the possibility of changes in regulations that may adversely affect the project must be considered. The project's risk posture must change to meet technology and increased public safety demands.

- Funding. The availability of financing and adequate cash flow is a major concern of all project participants. This concern also extends to factors such as interest rates, cost of borrowing capital, internal rate of return and net present value.
- The concession agreement and other contracts. As the binding force among the parties, these documents require a great deal of attention from each party. The contracts are essentially a risk allocation tool. However, the contract itself may be the source of risk when it is not clearly drafted or when contract administration is not efficient. These legal documents must clearly define and assign the risks borne by each party.

2. Management Actions. The management and administration of the project is another major source of risk. There are factors that can affect the overall project risk:

- Cost and schedule estimates. Inaccurate estimates or schedules yield unrealistic goals and inefficient project planning.
- Human errors. These include omissions, poor judgment, methodological errors, lack of knowledge and also misunderstandings.
- Timely decisions. Lack of prompt management action in case of problems increases risks to all project participants.

3. State of the world risks. There are sources of risk that are outside the limits of the project and beyond the control of its participants. This category includes risks such as inflation, political and labor issues, marketplace factors, etc.

- Inflation and currency exchange rates. The general economy of a country definitely impacts the risk level of a toll road project, reaching aspects such as financing, construction costs, traffic demand, etc.

- Political issues. The political environment of the country where the project is to be built affects exposure to risks. These issues include risk of government appropriation of the project, retention of dividend remissions, political unrest, etc.
- Marketplace. The marketplace forces that determine the traffic demand likely to sustain through the toll road route are a critical risk concern.

Risk Identification Techniques

Every infrastructure project is unique in nature. Risks associated with the project can be identified from historical data, and experience from similar projects. Sometimes, historical information is not enough for careful risk identification. Experience with similar projects enables a project team to better analyze the known data and associate it with the characteristics of the current project, even when historical records are insufficient or not available. If neither historical data nor previous experience is available, it is necessary to rely on insight. Even when data is available, the size and complexity of a major project make insight and subjective evaluations an essential element in the identification process (Diekmann, Sewester et al. 1988; Sanchez 1998).

Risk Measurement

Once the risks of the project have been identified, their magnitude must be assessed. There are two primary types of risk, first those that occur frequently and have a moderate impact, but whose cumulative impact can be substantial, and second, infrequent risks with a strong initial impact. Both of these strongly influence the feasibility of the project. Risks must be measured in order to establish whether the project is feasible or not, whether it should be further studied or abandoned, to assess the level of detail deemed by the analysis, and the acceptable level of risk for the project (Diekmann, Sewester et al. 1988). Risk measurement (quantification) can be described as the process of determining adequate measures of risk by assessing the likelihood of occurrence of all the outcomes associated with the risks identified, as well as the magnitude of such outcomes (Diekmann, Sewester et al. 1988).

Measures of Risk

Risk can be measured by the single or combined probability distribution functions (PDF) involved. There are a wide variety of forms and types of PDFs, each of which describes a range of possible values and their probability of occurrence. These include normal, lognormal, beta, uniform and triangular distributions. The measures of risk represented as PDF must conform to the rules of traditional probability theory. These rules are summarized by (Diekmann, Sewester et al. 1988) as follows: "I) the sum of the probabilities for all possible events must sum to 1.0, 2) the probability of any event must be a number between zero and one, 3) the impossible event has a probability of zero, and 4) the probability of joint events is the product of the probability that one event occurs and the probability that the other occurs, given that the first has occurred".

Detailed information is needed about a variable to know the exact shape of the probability function. Since such precise information is seldom known, it has to be subjectively determined or assumed. The two most crucial parameters of a PDF are the mean and the standard deviation. The mean (μ) is a measure of central tendency for the variable, and the standard deviation (σ) is a measure of the dispersion of the variable. For a given mean value, the larger the range of the variable, the larger the standard deviation. Hence, all other factors being equal, variables with large standard deviations are riskier than those with small standard deviations.

The mean is also known in risk analysis as the expected value of a variable. It can be seen as the weighted average value of the random variable, where the weighting factors are the probabilities of occurrence (Park 1997). Other PDF parameters include the mode and he median, which are two other measures of central tendency, and the third and higher moments about the mean that characterize the skewness and other features of the distribution function.

Risk Measurement Techniques

There is a variety of methods that can be used to measure risk. The choice of one depends mostly on the objectives of the analysis to be performed. The risk measure can be quantified by determining the combined effects of risk in traffic, economic factors, cash flow needs, construction and maintenance costs, etc. Some example of risk measurement techniques are risk probability of occurrence, volatility, risk on return of capital, and value at risk. Other forms of analysis such as sensitivity and stochastic analysis, measure the tradeoff on outcome (NPV, IRR, etc.) by altering the effects of risk factors (traffic, toll, cost etc.). Sensitivity analysis is a formalized method of testing the effects of the variation in the value of an individual variable at a time, on the project's overall profitability measure. It is a technique used to identify key variables that influence the profitability of the project and to judge their relative importance (Winfrey 1964). Monte Carlo simulation is a type of stochastic analysis that uses computer programs to repeatedly sample the PDF of the variables that influence the profitability of the project in order to determine the total variability in the overall profitability measure.

Project Risk Analysis and the Simulation Approach

Project risk analysis broadens the perspective of the decision-maker from a fixed set of assumptions, (which are essentially indecisive) to a more comprehensive view of the probable outcomes. A broader view may lead to a reconfiguration of the project, assist in the development of new strategies of meeting project objectives or responding to difficulties (Jones 1991), or in the worst case, to the definitive rejection of the project. Park defines the term project risk as the variability in the project's profitability measure (such as its NPV or IRR), or in other words, as the project's potential for loss (Park 1997). The aim of project risk analysis is to produce a PDF of its profitability measure that serves as a tool to make a better investment decision. From this PDF, the decision-maker can extract such valuable information as the expected value (mean) of the profitability measure, the extent to which other profitability measures vary from, or are clustered around, the standard deviation, and the best estimate of profit.

The investment decision can be improved by incorporating the variability information along with the expected value. The standard deviation is a measure of the dispersion of the distribution (risk), hence it is desirable to minimize it. That is, the smaller the standard deviation, the less the potential for loss (or gains) associated with the profitability measure. Therefore the ultimate investment choice depends on the decision-maker's preferences, or, how greatly he/she is willing to accept the variability to obtain a higher expected value. The fundamental question is, what is the level of risk he/she is willing to accept? This will depend on the investor’s attitude towards risk (whether the investor is risk averse, risk neutral or risk seeker). The objective of risk simulation is to weigh several structures of risk factors by their probabilities, and then summarize all the possible configurations and values of the risk factors into a risk profile for the project under examination (Jones 1991). The Monte Carlo simulation method is one of the most common risk simulation techniques.

Risk simulation operates with the probabilities of the variables influencing the outcome of the problem being analyzed i.e. in this case, the project profitability measure. These subjective probabilities are based, as mentioned earlier, on expert opinion and are supplemented by data about the objective frequencies of events, where available. The key to risk simulation lies in estimating these probabilities, which already exist, since people are willing to make decisions, such as whether or not to invest in a toll road project (Jones 1991).

Steps in Project Risk Analysis and Simulation

Summarizing the work of several authors (Adler 1987; Park 1997), the simulation approach for project risk analysis can be defined as a process consisting of the following steps:

- <u>Model the problem</u>. The model developed in the decision analysis process must be translated into equations for determining cash flows, profitability index and other economic measures.
- <u>Identify the major risk factors</u>. The process for risk identification must be established at the outset. In order to identify the most appropriate variables, a series of sensitivity analyses on the model is performed in this step. The elimination of non-sensitive variables will expedite the simulation process.
- <u>Run the simulation</u>. The performance of the investment is simulated with parameters sampled from the probability distributions developed for the various risk factors. This step can be entirely computer-based, that includes; sampling from the PDFs, forecasting

variables and calculating the cash flows. After a specified iterations (usually around 1,000), the program can provide the probability distribution of the profitability measure.

- Produce Risk Profile and Analyze Results. The summary of the results of the analysis is a risk profile or PDF for the profitability measure. This PDF provides the mean profitability measure, the range of potential outcomes, and the probability that the measure will fall between a particular range.

OTG STRATEGY

Ownership, Tenure and Governance (OTG) are the three principal components of a public private partnership. These three terms have specific meaning with explicit tasks to play.

- Ownership: A legal term signifying "exclusive rights of possessing, enjoying, and disposing" a property or a past thereof, as recorded in appropriate governmental document. The term 'ownership' has embedded in it the concept of 'possession' and 'title' related to the property in question. Depending upon the nature of the PPP project, its ownership of the property/facility may belong to the public entity, private entity, or both (joint ownership), during the concession period. Ownership is also likely to change at the end of the concession period.

- Tenure: A term used in describing "the condition of holding something in one's possession", or the status of holding a possession for a specific period, ranging from few days to a very long time. For most PPP projects, tenure is likely to coincide with the concession period; however, exception to this general rule may be encountered.

- Governance: The term "Governance" is derived from a Greek verb meaning 'to steer', and essentially refers to the process of management, policy making, and decision rights pertaining to an organization set up with the intent of producing a pattern of desirable results, and avoiding undesirable consequences. The world bank[4] defines governance as "The exercise of political authority and the use of institutional resources to manage society's problems and affairs." A fair governance is expected to outline the relationship between all project stakeholders ensuring the proper flow of information, to permit proper review prior to critical decisions[5]. For PPP projects, stakeholders include: management, owners, employees, banks, and lenders, customers, and other project partners. Since PPP projects involves such divergent group of stakeholders, the identification of a proper governance structure is considered to be a key prerequisite to successful PPP operation.

SUMMARY

A summary of the literature review is presented below;

- The rationale of choosing PPP is to extend the financial support of public agency to the private agency for better operation and maintenance of the facility; and for sharing possible risks if encountered in future.
- Various forms of PPP can be structured based on the responsibility shared between public and private entity. Other factors such as funds invested, benefits accrued, and tenure of operation can influence PPP strategies
- Long term infrastructure projects are typically characterized by two factors: uncertainty and risk

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4 World Bank, "Managing Development-The Governance Dimensions" 1999, Washington, D. C. http://www-wdc.worldbank.org/external/default/WDSContentServer/WDSP/IB/2006/03/07/000090341-20060307104630.

5 Patrick S. Renz. Project Governance: Implementing Corporate Governance and Business Ethics in Non-Profit Organizations". Heidelberg:Physcia-Verb 2007 (Contributions to Economics).

- The distinction between risk and uncertainty is discussed
- Sources of uncertainty can arise from travel demand, journey time; and other cost factors
- Risk is the outcome of uncertainty and must be identified
- Risk should be properly analyzed, measured and quantified
- OTG strategies of PPP projects are discussed

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CHAPTER 3
Phase-I Summary

One of the recent papers by the authors dealing with the economic evaluation of OTG strategies for the proposed Detroit river crossing is attached in Appendix A. The approach used in this paper is based upon the assumption of cost/revenue stream that are deterministic in nature. Thus, the analysis presented does not incorporate the consideration of risk and uncertainty discussed in the report. However, it defines the fundamental nature of the framework proposed in this study.

Results presented in this paper indicate that the method used for testing alternate OTG strategies is viable and can be used to test the implications of varying roles by the participating entities, including the private and public sector. The framework presented in this chapter will be used to enhance the economic evaluation of the Detroit river crossing, by incorporating risks and uncertainty in the decision-making process. Additionally, cost and revenue data, used in the attached paper will be updated to reflect the most current state of affairs pertaining to the project. A brief description of the current status is presented at the end of this chapter.

During the last few years, a number of studies have been undertaken by the Michigan Department of Transportation and the Ontario Ministry of Transportation to investigate the need, location and type of a proposed third river crossing connecting the cities of Detroit and Windsor. These studies appear to indicate a strong need for such a river crossing. Studies are currently underway to determine its location, access and type (tunnel, bridge, etc). No decision been made on the Ownership, Tenure and Governance (OTG) of the proposed crossing, nor has there been a study to address the issue of OTG.

The purpose of this study is to develop an analytic framework that can be used to test alternative OTG strategies for the proposed river crossing, including public, private and various joint ownership scenarios. Along with other details, the framework to be developed in this study will incorporate the concept of "investment decision under uncertainty." Estimates of the project costs and benefits (particularly those beyond the immediate future) are likely to be characterized by significant variances. The uncertainties and risks associated with these estimates will be incorporated in the proposed framework. The framework developed will be tested with data that may be available from different published reports and from the Michigan Department of Transportation.

The broad purpose of Phase I was to establish the initial analytic framework around which different OTG strategies can be identified and tested. Phase II is devoted to more detailed testing of the framework with demographic, socio-economic, travel demand and cost data relative to the local area and the bridge. The functional interface between two phases is presented in Figure 3.1. In this chapter a synopsis of the analytic framework is presented along with discussion on how the framework will be used in Phase II. This framework is currently being subjected to a test network in Phase II. The purpose of this initial test is to identify specific components of the framework that may need revisions. On successful completion of this test, the testing of the framework with actual data will be started. A majority of the data needed for analysis has already been collected.

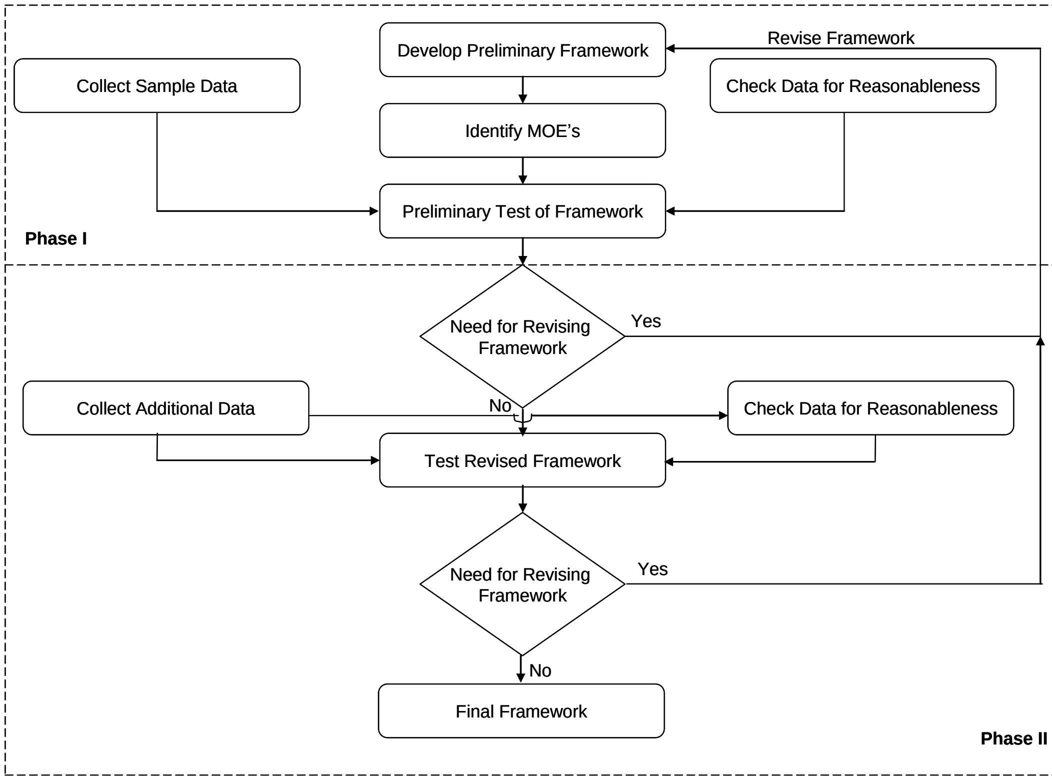

Figure 3.1 : Interfaces of Phase I and Phase II

A database consisting of a list of toll bridges and tunnels in the US, along with toll rates, toll rate growth, construction history, geometric characteristics and other historical data has been prepared. Contact information for each facility is also recorded for future interactions. Reports on economic and financial analysis are procured from corresponding websites. A comprehensive list of data requirements for testing alternate OTG strategies has been prepared and divided into the following categories:

- GIS data of traffic analysis zones and network geometry
- Socioeconomic and Demographic Data
- Trip matrices
- Cost elements of the proposed bridge
- Proposed toll structure.

Framework Development

The proposed framework is being developed to incorporate the concept of investment decisions under uncertainty and risk. A framework in this case, is a system of procedures/algorithms integrated together through appropriate linkages to produce a designed output. For large scale systems, these linkages are developed through many iterations of application that require the availability of appropriate databases. The collection of such databases is beyond the scope of the project. However, a reasonable set of data is available from a number of studies/reports completed under the auspices of the Michigan Department of Transportation. These data will be used for testing the framework.

An initial framework developed is illustrated in Figure 3.2 and categorized into four steps;

- Step 1: Development of Policy Options
- Step2: Development of Optimization Process
- Step 3: Testing of Various Investment Options
- Step 4: Assessment of Results and Identification of Viable Solution

The first step is an examination of the investment policy options recommended by the federal and state levels relating to new transportation projects. A series of PPP's (or policy options identified in Figure 3.2) will be considered where the responsibilities of the public and private agencies may vary a wide range. At one end of the spectrum, the public entity may have all the major responsibilities with the private agency playing a minor role. At the other end, the roles may be reversed. Various other combinations may form the intermediate range.

An evaluation of the proposed OTG strategies can be viewed as a bi-level process (Step 2). The policy maker (upper level) is assumed to have knowledge on how the road users (lower level) would respond to a given strategy. However, the strategy set by the policy maker can only influence (but not control) the road users’ route choice (or use of the proposed facility). In other words, policy options and route choice decisions to some extent, are inter-dependent and can be represented as a bi-level program, where, the upper level involves policy maker’s decision to determine the toll value and the lower level assigns number of road users to the proposed facility for the toll structure determined in the upper level. This is an iterative process carried out until the a specific toll value and traffic volume determine optimal benefit subject to various constraints imposed by construction, operation and maintenance costs. Cash flow diagram over the entire life cycle of the facility will be considered. Economic and financial measures of effectiveness will be determined to check the viability of the project. (Step 2).

Various investment options identified in step 1 can be considered as per viability of the project. Policy regulations such as construction cost subsidy, concession period extension, etc. can be considered if the project is not viable to promote private entities interest in investment. After relaxation of policy regulations viability of the project can be recomputed and a set of OTG strategies can be developed and tested (Step 3). The first three steps takes into account the uncertainty in demand (number of road users using the facility) subjected to various toll values.

In step 4 risks associated with set of OTG strategies are determined. Value at risk for a policy option is the most expected loss over a given horizon at a given confidence level. Risky policy options can be avoided at this step and feasible ones can be considered as favorable for future investment.

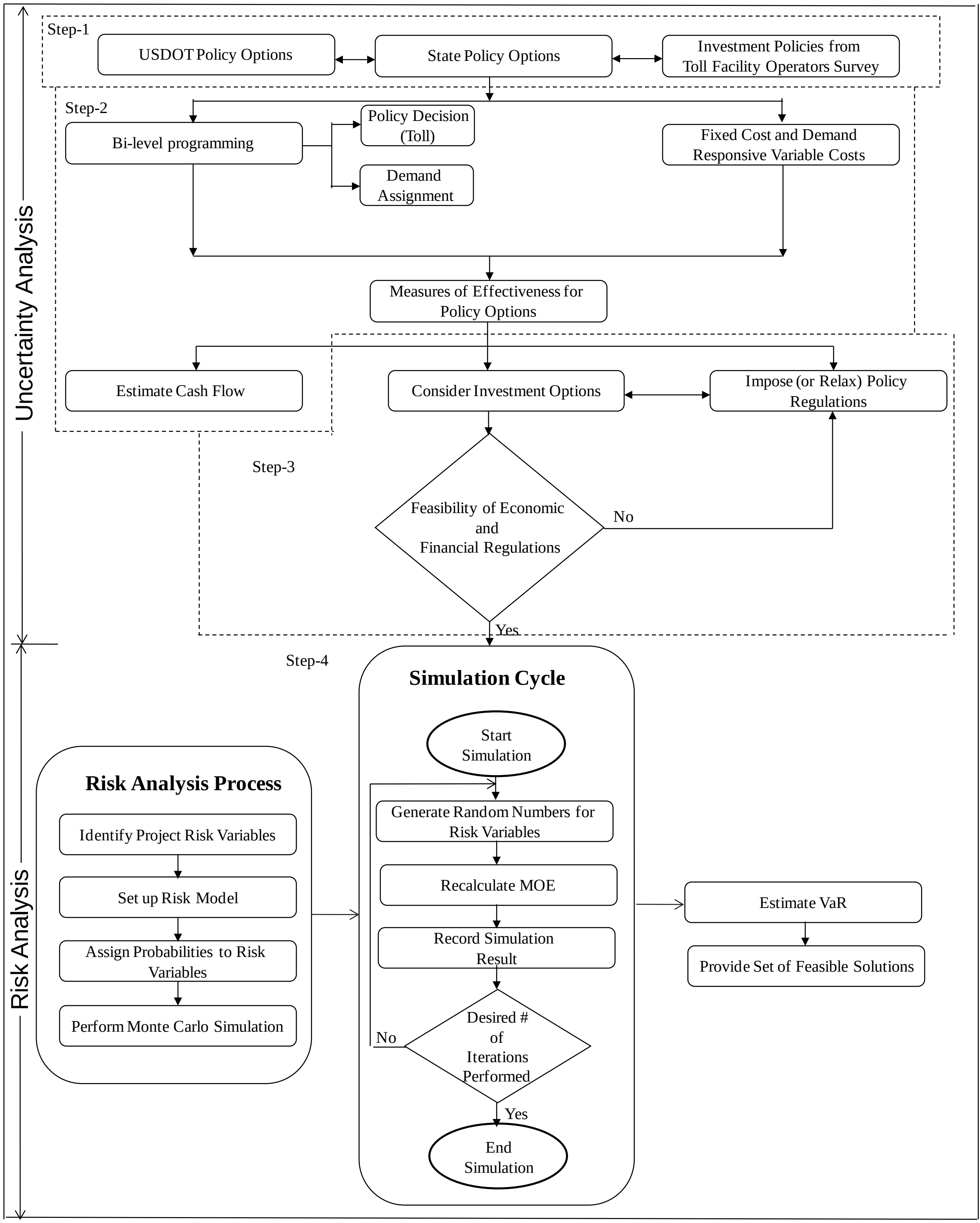

Figure 3.2: Proposed Methodology

Decision Tool for Uncertainty Analysis

Investments in major transportation infrastructure are often complex, with a mix of public and private finance, with the respective agencies having different missions and motivations. The public sector may consist of national, state and local administration with intent to adopt a social welfare perspective. The public and private entities are interested in exploring optimal tolling strategies that may yield different solution (Wong, Noland et al. 2005; Palma, Lindsey et al. 2006; Rouwendal and Verhoef 2006; Hyman and Mayhew 2008). While the public entity always would like to maximize the social welfare; the private entity is likely to be interested in maximizing the net profit. The private participation will occur only if the investment is attractive to maximize its benefit. Since the public sector will be eventually be the owner and operator of the facility; it must ensure that the facility attracts users and serve needs of the community (Yang and Meng 2000). Finally, the optimal toll must be viable to the ultimate end users. From basic user perspective; the toll value should be such that it attracts vehicles to meet the mobility needs of the community thereby ensuring spatial equity among users.

The methodology for uncertainty analysis is presented in Figure 3.2 (Step1 – Step-3). In the bi-level process, the upper level is subdivided into three categories considering the nature of PPP project and they are; (1) Private Investor’s perspective, (2) Public Investor’s perspective, (3) Road User’s Perspective. The objectives of these three entities are different. For example, the private entity perspective is to maximize profit, while the public entity perspective is to maximize social welfare, and the user perspective is to minimize inequality. While the designed toll value for all the three perspectives will be different at the upper level, the lower level is a user equilibrium assignment problem with elastic demand which is designed to consider the uncertainty in travel pattern.

Sources of uncertainty in the transportation infrastructure investment can arise from future cost and revenue. While bulk of the cost element is from construction cost which is spent before the facility is opened to traffic; other future cost elements such as regular operation and maintenance; and periodic operation and maintenance depends on future travel demand. On the other hand, revenue is directly dependent on travel demand and toll. Uncertainty for both cost and revenue is primarily generated from travel demand. In this research, a framework is proposed to address uncertainty by considering random expected potential and variance of travel demand from one zone to the other. Different accuracy levels are considered based on the variance of travel demand. Further, different accuracy levels of travel demand are used in the bi-level optimization process to determine optimum toll, corresponding traffic volume and future operation and maintenance cost.

Policy Option-1: Private Investor's Perspective

The objective of the private investor is to maximize profit. The annual profit for demand uncertainty is the difference between benefit and cost and is presented as follows (Chen and Subprasom 2007).

$$P^n\left(\tau, x\left(\tau, \varepsilon\right)\right) = B^n - C^n \tag{1}$$

Where, P^n is the profit generated in year n, which is a function of the demand (x) and toll (τ). B^n and C^n are corresponding revenue and cost for year n respectively. The revenue generated is a function of uncertain demand and toll, while the cost is can presented in the form of capital and operation and maintenance cost.

Policy Option-2: Public Investor's Perspective

The objective of the public investor is to maximize the social welfare which can be attributed as the economic benefit to the society. The annual social welfare for demand uncertainty can be defined as the difference between the consumer surplus and the cost of the project (Yang and Meng 2000; Chen and Subprasom 2007). Further, consumer surplus is categorized as the difference between willingness to pay and the amount actually paid for travel from one zone to the other.

Policy Option-3: Road User's Perspective

The benefits and costs of the project for all OD pairs must be reasonably distributed to establish spatial equity which is the objective from road user's view point. If the implementation of project only benefits a small section of travelers in the study area, then the distribution will not be called as equitable. There is variety of indices used to measure inequlity and one of the commonly used is Theil T index. If every zone has same benefit then the theil index is zero, and if the benefit is concentrated at one zone then the Theil index is $\ln d^n$, where d^n is the total demand for year n. Lower the Theil index better more equitable is the project.

While the upper level program determines the toll for various perspectives considered, the lower level determines the route choice of users for a designed toll value subjected to uncertain demand. The lower level problem is a user equilibrium traffic assignment with elastic demand (Sheffi 1985).

Multi-objective Optimization

A single objective optimization is imperative from a specific entity perspective. The optimum solution thus obtained might not be best suited to other entities. A multi-objective optimization (MOO), the process of simultaneously considering two or more objective functions each with a specific optimization defined, is proposed considering perspective of all three entities. Different solutions of MOO may produce conflicting solutions (trade-offs) among different objectives. A solution that is optimal with respect to one objective might require a compromise for others. MOO provides a pareto-efficient front to choose from a set of sub optimal solutions. A multiobjective optimization process can be used to obtain to attain an optimal solution in the presence of two or more conflicting objectives (Sawaragi, Nakayama et al. 1985; Deb 2001). The optimization framework currently being developed as a part of the proposed methodology will consider the perspective of the private entity, public entity, and the user.

Decision Tool for Risk Analysis (DTRA)

In the first three steps we have determined the demand and corresponding toll taking into consideration the demand uncertainty. Now how valid these investments are subjected to risk can further be tested. Risk analysis could provide a wide range of potential revenue outcomes to the project under consideration; which may identify the undefined levels of risk. Accordingly, risk analysis should be undertaken to identify the probability of revenues reaching particular levels in specified planning periods.

Risk is often defined as the probability of occurrence of an undesirable outcome. A single and multiple variable stochastic approach is proposed in this study. The risk analysis in this paper consists of simulating the various inputs for the life of the project and finding the present value.

This process is repeated number of times using Monte Carlo Simulation to incorporate risks from multiple sources both on revenues as well as costs. In this manner the net present values associated with the project is obtained.

The proposed methodology for DTRA is presented in the step-4 of Figure 3.2. In the proposed risk analysis, a monte carlo simulation (MCS) model will be used, which employs pre-defined probability distributions to analyze the effect of indecisive inputs on outputs of the modeled system. The volatility of inputs is expressed through defining their bounds according to the data points required by the input distributions. For example, triangular distribution requires high, low, and most likely values. Output variables resulting from computer simulations are also characterized by probability distributions having means (averages) and standard deviations (measures of internal dispersion). A cumulative distribution function describes the total probability or likelihood of occurrence at any level of output variable. Thus a MCS risk analysis describes the effect of the volatility of input variables on the simulation output.

MCS is a stochastic simulation process that uses continuous probability distribution for inputs variables to predict every possible outcome by randomly generating values for variables over. In general, the techniques in a MCS for the probabilistic risk analysis of projects include four steps: a) Developing a model by building of project; b) Identifying the model inputs, project risk variables such as interest rates, exchange rates, completion dates, and costs; c) Specifying the risk variables, their possible values with probability distributions, and identifying the results for the analysis; d) Analyzing the model with simulation to determine the range and probabilities of all possible outcomes for the results of a project.

Measure of Risk

Risk can be quantified and measured in different ways (Mun 2006). Value at Risk (VaR) is one of such methods and used in Decision Tool for Risk Analysis (DTRA). VaR can be defined as the maximum loss over a target horizon, with a given level of confidence (Jorion 1997). VaR[6] describes the quantile of the projected distributions of gains and losses over the target horizon. If α is the selected confidence level, VaR corresponds to the 1- α lower tail level. For example for 90 percent confidence level, VaR should be such that it exceeds 10 percent of the total number of observations in the distribution.

VaR can be computed once the price path is simulated, and the resulting MOE (say NPV or IRR) can be developed at the end of the selected horizon. The simulation can be carried out in the following steps.

- Choose a stochastic process and parameters
- Generate random numbers of variables from which the prices are computed as S_{t+1} , S_{t+2}, ... S_{t+n}
- Calculate the value of the infrastructure under this particular sequence of prices at the target horizon.
- Repeat steps 2 and 3 for higher number of iterations (say more than 1,000)

Summary

Proposed methodology presented in this chapter can be summarized as follows;

- Three principal entities involved in the success of a PPP project is; the private; the public and the road user.

[6] Jorion, P. (1997). Value at risk: the new benchmark for controlling market risk, McGraw-Hill.

- Objective of these three entities are different. The private entity would like to maximize revenue (tangible). The objectives of the public entity and the user are to maximize social surplus (both tangible and intangible), and to minimize spatial inequity respectively.
- The uncertainty analysis approach is designed in a bi-level programming; where the first level considers various entity perspective (profit maximization; welfare maximization, and inequality minimization), and the second level considers the uncertainty in travel demand.
- Uncertainty in transportation infrastructure is mainly generated from travel demand, which has direct effect on the revenue.
- Travel demand uncertainty is considered by traffic assignment with elastic demand.
- The uncertainty analysis results in optimal design of toll structure for three entities of interest (private, public, and user).
- If the toll structure does not attract private investors, relaxation on policies can be proposed. Policy relaxation includes reduction in construction cost share for private entity; increased concession period; etc.
- Risk follows uncertainty; and the expected loss in various scenarios need to be estimated. A stochastic risk analysis approach is proposed.
- Monte Carlo Simulation is used to estimate the VaR
- The result of uncertainty and risk analysis can be used to test different OTG strategies and to identify most desirable form of PPP for transportation infrastructure investment.

Anticipated Results

The anticipated results of this study include:

- Identification of Various Ownership, Tenure and Governance (OTG) strategies of the proposed Detroit River crossing infrastructure, ranging from public ownership, private ownership and PPP options, encompassing various forms of Build, Own, Operate and Transfer (BOOT) concepts.
- Identification of Barriers and Opportunities associated with different OTG strategies.
- Development of an Analytic Framework to test the economic consequences of various OTG strategies, along with data requirements, and Measures of Effectiveness.
- Results of testing

Current Status

The Detroit River International Crossing (DRIC) study undertaken by the MDOT, FHWA, Ontario Ministry of Transportation and Transport Canada was initiated a number of years back to establish the need of a second bridge connecting Detroit and Windsor, to identify and evaluate alternative location and types of crossing, and to prepare Draft Environmental Impact Statements (DEIS) for the feasible alternatives. The DEIS thus generated were subjected to public review process as required by law.

A recent (Jan 15, 2009) press release by MDOT shows that USDOT has approved plans for a second border crossing between Michigan and Ontario. The Draft Environmental Impact Study (DEIS), undertaken as a part of DRIC has resulted in a Record of Decision (ROD) signed on Jan 14, 2009. The ROD represents environmental clearance for the DRIC study for the border crossing between Detroit and Windsor, north of Zug Island. The ROD is also considered as the last step under the National Environmental Protection Act (NEPA) for project approval following public hearings, traffic and environmental studies. This ROD will, thus clear the way for the state (MDOT) to start the process of acquisition of the right of way, needed for planning and construction of the bridge. The tentative date of opening of the bridge is during the year 2013.

A second news item reported in the Detroit Free Press on January 29, 2009 states that USDOT has approved plans proposed by the owner of the privately owned Ambassador Bridge to "borrow nearly $800 million to pay for the construction of a second span next to the Ambassador Bridge". The news article also mentions that the USDOT also agreed on the final environmental approval to build a publicly owned bridge between Detroit and Windsor. This publicly owned bridge is the bridge for which approval was granted to MDOT by way of the ROD mentioned earlier.

Clearly, there is sufficient interest both at the public and private level to build a second bridge. The proposed locations are different, but are close proximity of each other. It is also abundantly clear that long term demand projections can justify only one bridge (either the Zug Island bridge or the second Ambassador Bridge), but not both. The above developments underscore the importance of a PPP approach, and the development of appropriate OTG strategies to implement the construction, operation and maintenance of the proposed bridge, either at Zug Island or the second span nest to the Ambassador bridge.

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Appendix-A

A Framework for Analyzing the Ownership, Tenure and Governance Issues for a Proposed International River Crossing

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A Framework for Analyzing the Ownership, Tenure and Governance Issues for a Proposed International River Crossing

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ABSTRACT

In this paper the authors present a framework for analyzing different Ownership, Tenure and Governance (OTG) strategies for a proposed international river crossing in Detroit, Michigan that constitutes a major trade corridor between the US with Canada. The framework is designed to identify an economic analysis procedure that can be used to test the fiscal consequences of different OTG strategies, including public ownership, private ownership and joint ownership. The authors also demonstrate the application of the procedure with limited data and conclude that the framework is viable and can be used to test the economic consequences of various OTG strategies. Recommendations for future research include procedures to incorporate intangibles; risks/uncertainties associated with future economic outcomes; and various joint ownership scenarios.

Keywords: Ownership, Tenure, Governance, Risks, Uncertainties

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1. INTRODUCTION

The trillion dollar transportation infrastructure in the US has been financed primarily by public dollars through various forms of user taxes (Garber and Hoel, 2002). The Highway Trust Fund created by Congress in the mid-1950s was used to build the interstate highway system (formally the Defense Highway System) that serves as the backbone of the nation's transportation network today and that has provided much of the stimulus for regional economic growth. Since the completion of the interstate system in the early 1990s, Congress has taken a number of landmark legislative actions to support the transportation infrastructure in the US. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the 1998 Transportation Equity Act for the 21st Century (TEA-21), and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETY-LU) of 2005 will have provided over $700 billion of support for the transportation infrastructure of the country for the period 1992 through 2010. The intent of these acts is to develop and maintain a multimodal transportation system that is economically efficient and environmentally sound, and that will enable the nation to compete in global economy.

Historically, the highway infrastructure in the US has been built and maintained by public funds, with a few exceptions. Factors such as improved mobility, reduced congestion, and higher safety, along with economic benefits have been used to justify these investments. Tollways and turnpikes, regardless of tenure, constitute a small fraction of US highways, and are somewhat of an exception to this rule. Typically, these facilities are financed by long-term bonds, and the revenue generated by the facilities is used to pay for the investment. Only limited private funding has been used in the U.S. for roadway infrastructure. Private participation is, however, more common in other modes of transportation, particularly rail, air and transit prior to 1950s.

Programs for these modes have been characterized by sharing of costs and revenues by the private and the public enterprise.

1.1 Background Information

The purpose of the above discussion is to provide a background of this paper focusing on a proposed international crossing across the Detroit River in the Midwest, connecting the cities of Detroit, USA and Windsor, Canada. The Central Business Districts (CBDs) of the cities of Detroit and Windsor are currently connected by a bridge and a tunnel across the Detroit River, both built during the late 1920s. The Ambassador Bridge is a privately owned four-lane suspension structure, while the Detroit-Windsor tunnel is a two-lane facility with height restriction, jointly owned by the two cities and operated by a private corporation. These two facilities constitute one-half of the vital trade-corridor between the US and Canada in the Midwest.[11] The vehicular crossings between Southwest Ontario and Southeast Michigan are the busiest of all Canada-US border crossings, and the Ambassador Bridge ranks the highest in commercial vehicles among all US border crossings.

A number of recently completed and ongoing studies sponsored by the Michigan Department of Transportation (MDOT) and the Ontario Ministry of Transportation (OMT) consider various issues related to a new Detroit River crossing, two of which have direct relevance to this paper. The Canada–US–Ontario–Michigan Transportation Partnership Study (Partnership Study) attempted to develop long-term strategies to provide for safe and efficient

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[11] Two other facilities carry freight between Michigan and Ontario. A rail tunnel under the Detroit River at Detroit and the Blue Water Bridge over the St. Clair River (100 km north of Detroit), which connects Port Huron, USA and Sarnia, Canada.

movement of people and goods between Michigan and Ontario (FHWA, 2003). Even though the current capacities of the Ambassador Bridge and the Detroit-Windsor tunnel adequately serve the traffic needs during most hours, on specific days during peak periods the systems do run at full capacity. Considering long-term traffic growth and the overall importance of the Detroit River crossings on the regional economy, the need for a third crossing seems immensely justified.

A second ongoing study–Evaluation of Alternatives from US and Canadian Sides of the Border–explores various alternatives for the proposed new crossing and is expected to recommend the most-desired alternative, based upon a set of comprehensive Environmental Impact Statements (FHWA, 2003). This study originally identified a total of 15 alternatives, depicting different bridge structures, plaza locations and connecting routes, that have been narrowed down to three, based upon context-sensitive design considerations, expert opinions, and technical viewpoint.

1.2 Problem Statement

The United States and Canada share the largest trading relationship in the world. Currently $200 billion of surface trade passes annually between Southwestern Ontario and Southeastern Michigan, a figure expected to reach $300 billion by the year 2030 (FHWA, 2003). More than 50% of this traffic crosses the Detroit River by truck (FHWA, 2003). This large trade volume has a significant positive effect on the local, regional and national economies, through cross-border employment, opportunities. The vehicular crossings between Southwest Ontario and Southeast Michigan are the busiest of all Canada-US border crossings, and the Ambassador Bridge ranks the highest in commercial vehicles among all US border crossings (MDOT and OTM, 2003).

The Ambassador Bridge (a four lane facility) , on an average day, carries approximately 26,500 passenger-cars and 12,000 commercial vehicles and these figures are projected to increase by more than 40% and 100% respectively by the year 2030 (FHWA, 2003). The corresponding figures for the Detroit-Windsor Tunnel (a two lane facility) are 25,000 and 700 with projected increases of 100% and 30% respectively by 2030 (FHWA, 2003). The long-range prediction of the trade volume clearly indicates that the two existing Detroit River vehicular crossings (and any additional crossing that may be opened in the future) will have a major part in the overall economic picture of the Southeast Michigan and Southwest Ontario region, not to mention the cities of Detroit and Windsor.

Research presented in this paper is built upon the premise that a new crossing, most likely in the form of a bridge, will be built in the near future, even though its exact location is yet to be determined. The problem investigated in this paper relates to the development of an analytical framework designed to address the issues of Ownership, Tenure and Governance (OTG) of the proposed facility. Research envisioned in the future will explore the OTG issues related to the proposed facility using the framework presented. The proposed framework can be used to conduct exploratory analysis on questions such as, “Should the new crossing be owned, operated and governed by a (yet to be named) public agency, so that the taxpayers can benefit from the revenues likely to be generated over the life of the project?” Or, “Should the ownership and operating rights be left to the private enterprise, thereby protecting the public at large from the risks associated with this investment?” A third alternative would be joint public-private ownership with clearly defined rights and responsibilities in the operation and governance of this proposed crossing.

1.3 Study Objectives

The objectives of the research presented in this paper are to

1. Develop a framework for economic analysis to explore the Ownership, Tenure and Governance (OTG) issues of the proposed river crossing;
2. Identify data requirements associated with using the proposed framework to analyze different forms of OTG issues of the proposed facility; and
3. Demonstrate the application of the proposed framework with limited data.

2.0 ANALYTICAL FRAMEWORK

The framework for economic analysis developed for the study is adapted after the concepts of Benefit to Cost Ratio (B/C) and Internal Rate of Return (IRR). The following symbols are used are introduced to explain the methodology

(A/F) = Sinking Fund Factor

(A/P) = Capital Recovery Factor

APOM=Annualized worth of POM

B = Project Benefits in Year 1

(B/C) = Benefit Cost Ratio

C = Unit $ Value of Each Accident Prevented

(C/E) = Cost Effectiveness Index

EUAB = Equivalent Uniform Annual Benefit ($/year)

EUAC = Equivalent Uniform Annual Cost ($/year)

I = Initial Cost ($)

i = Interest rate used (%, annual)

IRR = Internal Rate of Return (%, annual)

K = Annual Operating and Maintenance Cost ($)

MARR = Minimum Attractive Rate (%, annual)

PWOB=Present Worth of Benefit

PWOC= Present Worth of Cost

(P/A) = Present Worth Factor (Uniform Series)

(P/F) = Present Worth Factor (Single Payment)

(PP) = Pay off Period (years)

POM= Periodic Operation and Maintnance(O&M) Cost ($)

PWOB = Present Worth of Benefit ($)

PWOC = Present Worth of Cost ($)

S = Salvage Value ($)

$y_1, y_2, y_3 .... y_n$ *=Years when Periodic (O & M) Cost is Applied*

g = Annual Growth Rate

2.1 Benefit Cost Analysis

Benefit to Cost Ratio is one of the most frequently used methods in economic analysis. B/C Ratio is simply a measure of the number of units of benefits that the project is expected to provide per unit cost. The algorithm typically used is

$$\frac{B}{C} = \frac{Benefit}{Cost} = \frac{EUAB}{EUAC}$$

$$EUAC = I \times \left(\frac{A}{P}\right) + K + POM \times \left[\left(\frac{P}{F}\right)_{n=y_1} + \left(\frac{P}{F}\right)_{n=y_2} + ... + \left(\frac{P}{F}\right)_{n=y_n} \right] \times \left(\frac{A}{P}\right) - S\left(\frac{A}{F}\right)$$

$$EUAB = B \times \left(\frac{P}{A}\right)_{i,n,g} \times \left(\frac{A}{P}\right)_{i,n}$$

where EUAB and EUAC are Equivalent Uniform Annual Benefits and Equivalent Uniform Annual Costs respectively. Furthermore, EUAB and EUAC should include all tangible and intangible benefits associated with the project and should incorporate not only the toll revenues (tangible), but also the benefits associated with increased mobility, possible economic benefits, reduced congestion, and environmental benefit resulting from the project.

EUAC should incorporate all costs associated with the project including agency costs, user costs, and non user cost (Sinha, 2005), where

Agency Cost = Capital Cost + Operating Cost + Maintenance Cost;

Capital Cost = Planning, Engineering, Design, Right of Way and Construction Costs;

User Cost = Cost associated with vehicle operation, travel time, delay and safety; and

Non-User Cost = Costs of Environmental Damage (e.g., air pollution, noise pollution).

Furthermore, savings in user cost and non-user cost can also be treated as a part of benefits when two alternatives are considered, in which case these do not have to be accounted for separately as a part of the cost.

2.2 Internal Rate of Return Technique (IRR)

The IRR technique is also quite frequently used in economic analysis and requires the estimation of the interest rate that the project is expected to return to the investor. IRR is the interest rate at which the Net Present Worth or Net Annual Worth equals to zero. Projects that generate IRR values exceeding an initially specified Minimum Attractive Rate of Return (MARR) are considered viable. The MARR is used to judge the attractiveness of proposed investments, and represents a bench-mark yield below which all investment proposals are considered unattractive. The determination of MARR is normally a policy issue and criteria for setting it vary greatly.

2.3 Data Sources

Most of the data used in testing the analytic framework was obtained from various reports published by MDOT, often supplemented with information obtained through personal interviews (URS Canada, 2005). The accuracy of the data is not of great significance here, as the object of this analysis is simply to test the viability of the framework. The results presented are not intended to be a basis for any action at this time. Future research envisioned will be directed toward testing the framework with more authentic data, taking into account factors such as risks and uncertainties, intangible benefits and various forms of joint ownership scenarios under the Built, Own, Operate and Transfer (BOOT) concept as practiced in many European countries (Merna and Njra, 1995).

2.4 Alternative Scenarios

A total of five alternative OTG scenarios were developed, representing various levels of cost-revenue allocation as explained in Table 1. Cost and benefit elements of each project are presented in Table 2. As Table 1 shows, of these five scenarios, the first four are all public ownership models depicting how the capital costs of the bridge, plaza and access infrastructure are considered a part of the investment cost. Since the cost of the plaza and access infrastructure are much higher than that of the bridge itself, the extent to which these costs should be considered a part of the investment is a matter of argument. Scenarios 1 through 4 are designed to address this issue, by allocating these costs in different manners. Scenario 5 is a joint public-private ownership strategy that may be considered an outgrowth of Scenario 1. Furthermore, for each of these five scenarios, two alternatives are tested. These are

- Alternative 1: Least Capital Cost Intensive, as identified by the EIS being developed. (FHWA, 2003 and FHWA, 2005).
- Alternative 2: Most Capital Cost Intensive, as identified by the EIS currently being developed. (FHWA, 2003 and FHWA, 2005).

Thus, the five scenarios presented combined with the two alternatives, resulting a total of 10 mutually exclusive projects. Furthermore, these 10 projects are tested in two cases, (i) Case-1: 1.5% growth of both passenger cars and commercial vehicles (ii) Case-2: 1.5% growth of passenger cars and 3% growth of commercial vehicles. These 20 projects are demonstrated in a matrix form in Table 3. Since truck toll charges constitute the main source of revenue (tangible benefits) for the proposed project, two cases were analyzed depicting different growth rates for truck traffic.

3. RESULTS

Results of testing the proposed framework for 1.5% projected truck traffic growth (Case-1) are presented for the five scenarios for alternatives 1 and 2 in Tables 4 and 5. In Table 4, the relevant cost and benefit data are computed based upon the algorithm presented earlier. Two sets of Measures of Effectiveness (MOE) are presented in Table 5, B/C ratio and IRR. Interest rate or cost of borrowing capital was assumed as 6% in computing B/C ratio. Also, the MARR was assumed to be 6%, implying that any project generating an IRR less than 6% should be considered undesirable. Stated differently, projects generating an IRR less than the MARR are expected to result in a B/C ratio less than unity at the annual rate of 6%.

Table 5, which summarizes the economic analysis, shows that of all five scenarios, the B/C ratios for Alternative 1 (A-1) are higher than those of Alternative 2 (A-2). Since A-2 is more capital cost intensive, the above findings are logical. The same trend is generally true for the other MOE, (i.e. IRR). Furthermore, the highest IRR is attained in scenario 4, being equal to 7.3% and 7.1% respectively for A-1 and A-2. As mentioned earlier, the capital cost of the plaza and the access infrastructure is estimated to be much higher than that of the bridge itself. Since these costs are not considered to be part of the investment cost, the higher B/C ratio–the higher IRR for scenario 3 and scenario 4–are logical. Additionally, scenario 4 attempts to capture the externalities by increasing the benefits by 30%. Thus, the combination of these two factors (reduced cost and increased benefit) has the effect of maximizing the B/C ratio or IRR for scenario 4. On the other hand, scenario 1, which requires all capital costs (plaza and access included) to be borne by the public entirely, results in the lowest B/C ratio or lowest IRR.

Tables 6 and 7 are counterparts of Tables 4 and 5 respectively for the higher truck growth rate (3%). Increased truck traffic would result in increased revenue, resulting in higher B/C ratios and IRR values for Case 2 as compared to Case 1.[12] Overall, the results indicate that the proposed framework is viable and can be used to test various allocations of costs and benefits to the participating entities, which might include the public and/or private sector.

4. CONCLUSIONS AND RECOMMENDATIONS

The purpose of the research presented in this paper is to develop a framework for economic analysis to explore various OTG scenarios for a proposed Detroit River crossing

[12] Since this is simply a demonstration exercise to test the viability of framework, as opposed to an actual case study, the possible increased operating cost resulting from increased truck traffic was not considered in the analysis.

connecting the US with Canada. This research is based on the premise that a need for the third crossing in the general vicinity of two existing crossings in the Detroit-Windsor area will be built in the near future. A number of recent and ongoing studies will support the validity of the assumption.

The proposed framework for economic analysis was tested with limited data available for the study. While the results by themselves are of minor significance, the trends observed are important for assessing the validity of the framework. The trends appear to be logical, thereby attesting to the overall viability of the proposed framework. Even though only one joint public-private ownership scenario was tested, it is possible to test various scenarios under this concept using the framework developed. A Build, Own, Operate and Transfer (BOOT) scenario that seeks to raise capital funds from private resources, in exchange of future revenues is being used extensively in Europe and Asia for large scale infrastructure and can be used to develop different versions of the joint ownership scenario and tested using the proposed framework (Merna and Njra, 1995).

The proposed framework also should be refined to incorporate the concept of externalities (i.e., intangible costs and benefits) as well as the concept of uncertainty/risks associated with the estimation of future costs and revenues. For the public entity in particular, intangible outcomes comprise a major source of benefits and thus need to be accounted for in any economic analysis. Finally, the economic analysis presented is based upon expected project returns and costs during the life of the project (75 years), which have been considered fully deterministic. In effect, these future outcomes have significant amounts of uncertainty/risk associated with their estimate. Additional research is needed to incorporate the concept of

Investment Decisions Under Uncertainty with a more realistic assessment of future costs and revenues.

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LIST OF TABLES

Table 1: Proposed Scenarios, Cost and Benefit Elements

Scenario	Explanation	Cost Components (%)						Benefits(%) (Revenue)
		Planning and Design Cost	Capital Cost	Access and Plaza Cost	Toll Collection Cost (Annual)	Operation and Maintenance Cost (Annual)	Periodic Operation and Maintenance Cost	
1	1. Fully Publicly Owned	100	100	100	100	100	100	100
2	2. Fully Publicly Owned (50% of Plaza Cost)	100	100	50	100	100	100	100
3	3. Publicly Owned ("0" Plaza Cost)	100	100	0	100	100	100	100
4	4. Publicly Owned ("0" Plaza Cost) and 30% Increase in Benefits (Intangibles)	100	100	0	100	100	100	130 (30% factor include intangibles)
5	Public Private Partnership							
5a	Publicly Owned	100	50	50	100	50	50	75
5b	Privately Owned	0	50	0	0	50	50	25

Table 2 Alternatives and Cases for Proposed Scenarios

Cost and Benefit Items	Alternative-1 (Least Capital Intensive) in Millions	Alternative-2 (High Capital Intensive) in Millions	Case-1	Case-2
Planning and Design Cost	100	100	1.5% Growth of both Passenger Cars and Commercial Vehicles	1.5% Growth of Passenger Cars and 3% Growth of Commercial Vehicles
Construction Cost	250	500		
Access and Plaza Cost	850	1500		
Annual Operation and Maintenance (O&M) Cost	5 % of Construction Cost	3% of Construction Cost		
Periodic O&M Cost	(i)(N,20) =$25 (ii)(N,40)=$50 (iii) (N,60)=$75	(i)(N,20) =$30 (ii)(N,40)=$60 (iii) (N,60)=$90		
Toll Collection Cost (Annual)	10	10		
Benefits (First Year)	Total Revenue (B)	130% of B		

Table 3: Explanation of Scenarios, Cases, Alternatives and Projects

Scenario (*i* = 1 to 5)	Cases *(j =1, 2)*			
	Case-1		Case-2	
	Alternative-1 *(k=1)*	Alternative-2 *(k = 2)*	Alternative-1 *(k = 1)*	Alternative-2 *(k = 2)*
1	*111*	*112*	*121*	*122*
2				
3	ijk^*			
4				
5	*511*	*512*	*521*	*522*

Scenario: Refers to possible OTG strategies (a total of five)

Alternative: Refers to the level of capital cost (a total of two)

Cases: Refers to growth of commercial traffic (a total of two)

ijk^* : Project of scenario i, case j and alternative k

Table 4 Cost and Benefit Items -Case-1- (Commercial Vehicle Growth 1.5% and Passenger Car Growth 1.5%)

	Costs (In Millions)										**Annual Benefits (In Millions)**			
Possible Scenario	**Planning and Design Cost**	**Capital Cost**		**Access and Plaza Cost**		**Toll Collection Cost (Anuual)**	**Operation and Maintenance Cost (Anuual)**		**Periodic Operation and Maintenance Cost**		**Passenger Cars**	**Trucks**	**Passenger Cars**	**Trucks**
	A-1 &2	A-1	A-2	A-1	A-2	A-1 &2	A-1	A-2	A-1	A-2	A-1	A-1	A-2	A-2
1	$100	$250	$500	$850	$1,500	$10	$12.5	$15.0	(i)(N,20) = $25 (ii)(N,40)= $50 (iii) (N,60)= $75	(i)(N,20) =$30 (ii)(N,40)=$60 (iii) (N,60)= $90	$7.44	$23.76	$8.56	$27.32
2	$100	$250	$500	$425	$750	$10	$12.5	$15.0	(i)(N,20) = $25 (ii)(N,40)= $50 (iii) (N,60)= $75	(i)(N,20) =$30 (ii)(N,40)=$60 (iii) (N,60)= $90	$7.44	$23.76	$8.56	$27.32
3	$100	$250	$500	$0	$0	$10	$12.5	$15.0	(i)(N,20) = $25 (ii)(N,40)= $50 (iii) (N,60)= $75	(i)(N,20) =$30 (ii)(N,40)=$60 (iii) (N,60)= $90	$7.44	$23.76	$8.56	$27.32
4	$100	$250	$500	$0	$0	$10	$12.5	$15.0	(i)(N,20) = $25 (ii)(N,40)= $50 (iii) (N,60)= $75	(i)(N,20) =$30 (ii)(N,40)=$60 (iii) (N,60)= $90	$9.68	$30.88	$11.13	$35.52
5(a)	$100	$125	$250	$425	$750	$10	$6.3	$7.5	(i)(N,20) =$12.5 (ii)(N,40)=$25 (iii) (N,60)= $37.5	(i)(N,20) =$15 (ii)(N,40)= $30 (iii) (N,60)= $45	$5.58	$17.82	$6.42	$20.49
5(b)	$0	$125	$250	$0	$0	$0	$6.3	$7.5	(i)(N,20) =$12.5 (ii)(N,40)=$25 (iii) (N,60)= $37.5	(i)(N,20) =$15 (ii)(N,40)= $30 (iii) (N,60)= $45	$1.86	$5.94	$2.14	$6.83

Table 5 Results of Economic Analysis for Case-1

Possible Scenario	EUAB (i = 6%)		EUAC (i = 6%)		B/C (i = 6%)		IRR	
	A-1	A-2	A-1	A-2	A-1	A-2	A-1	A-2
1	$44.75	$51.47	$100.71	$161.36	0.444	0.319	3.6%	2.7%
2	$44.75	$51.47	$73.33	$113.05	0.610	0.455	4.7%	3.6%
3	$44.75	$51.47	$45.95	$64.74	0.974	0.795	5.7%	5.1%
4	$58.18	$66.90	$45.95	$64.74	1.266	1.033	7.3%	7.1%
5(a)	$33.56	$38.60	$58.57	$88.90	0.573	0.434	4.5%	3.6%
5(b)	$11.19	$12.87	$14.76	$24.15	0.758	0.533	4.9%	4.4%

Table 6: Cost and Benefit Items -Case-2- (Commercial Vehicle Growth 3% and Passenger Car Growth 1.5%)

Possible Scenario	Costs (In Millions)										Annual Benefits (In Millions)			
	Planning and Design Cost	**Capital Cost**		**Access and Plaza Cost**		**Toll Collection Cost (Anuual)**	**Operation and Maintenance Cost (Anuual)**		**Periodic Operation and Maintenance Cost**		**Passenger Cars**	**Trucks**	**Passenger Cars**	**Trucks**
	A-1 &2	A-1	A-2	A-1	A-2	A-1 &2	A-1	A-2	A-1	A-2	A-1	A-1	A-2	A-2
1	$100	$250	$500	$850	$1,500	$10	$12.5	$15.0	(i)(N,20) = $25 (ii)(N,40)= $50 (iii) (N,60)= $75	(i)(N,20) = $30 (ii)(N,40)= $60 (iii) (N,60)= $90	$7.44	$25.94	$8.56	$29.83
2	$100	$250	$500	$425	$750	$10	$12.5	$15.0	(i)(N,20) = $25 (ii)(N,40)= $50 (iii) (N,60)= $75	(i)(N,20) = $30 (ii)(N,40)= $60 (iii) (N,60)= $90	$7.44	$25.94	$8.56	$29.83
3	$100	$250	$500	$0	$0	$10	$12.5	$15.0	(i)(N,20) = $25 (ii)(N,40)= $50 (iii) (N,60)= $75	(i)(N,20) = $30 (ii)(N,40)= $60 (iii) (N,60)= $90	$7.44	$25.94	$8.56	$29.83
4	$100	$250	$500	$0	$0	$10	$12.5	$15.0	(i)(N,20) = $25 (ii)(N,40)= $50 (iii) (N,60)= $75	(i)(N,20) = $30 (ii)(N,40)= $60 (iii) (N,60)= $90	$9.68	$33.73	$11.13	$38.78
5(a)	$100	$125	$250	$425	$750	$10	$6.3	$7.5	(i)(N,20) = $12.5 (ii)(N,40)= $25 (iii) (N,60)= $37.5	(i)(N,20) = $15 (ii)(N,40)= $30 (iii) (N,60)= $45	$5.58	$19.46	$6.42	$22.38
5(b)	$0	$125	$250	$0	$0	$0	$6.3	$7.5	(i)(N,20) = $12.5 (ii)(N,40)= $25 (iii) (N,60)= $37.5	(i)(N,20) = $15 (ii)(N,40)= $30 (iii) (N,60)= $45	$1.86	$6.49	$2.14	$7.46

Table 7: Results of Economic Analysis for Case-2

Possible Scenario	EUAB (i = 6%)		EUAC (i = 6%)		B/C (i = 6%)		IRR	
	A-1	A-2	A-1	A-2	A-1	A-2	A-1	A-2
1	$59.05	$55.07	$100.71	$161.36	0.59	0.34	3.8%	2.9%
2	$59.05	$55.07	$73.33	$113.05	0.81	0.49	4.9%	4.0%
3	$59.05	$55.07	$45.95	$64.74	1.29	0.85	7.7%	5.6%
4	$76.77	$71.59	$45.95	$64.74	1.67	1.11	10.2%	7.2%
5(a)	$44.29	$41.30	$58.57	$88.90	0.76	0.46	4.6%	3.4%
5(b)	$14.76	$13.77	$14.76	$24.15	1.00	0.57	6.2%	4.4%

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Appendix B

Bridges

Table 1: List of Toll Bridges in US

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Antioch Bridge	CA	Antioch, California and Sacramento County, California	2	steel plate girder	9,504 feet (2,897 m)	1978	$4.00 (northbound)	FasTrack	N	N(State owned bridge)
Benicia-Martinez Bridge	CA	Martinez, California and Benicia, California	8	Truss bridge (southbound span), segmental bridge (northbound span)	1.7 miles (2.7 km)	1962	$4.00 (northbound)	FasTrack	N	N(Maintained by the California Department of Transportation)
Carquinez Bridge	CA	Crockett, California and Vallejo, California	8	2 Cantilever bridges and 1 Suspension bridge	0.66 miles (3465 feet / 1056.1 m / 1.06 km)	May 21, 1927 (original span) 1958 (eastbound) November 11, 2003 (westbound)	$4.00 (eastbound)	FasTrack	N	N(Maintained by the California Department of Transportation)
Dumbarton Bridge (California)	CA	Menlo Park, California and Fremont, California	6	The approach spans on both sides of the Bay are of pre-stressed lightweight concrete girders supporting a lightweight concrete deck.	2,621.28 meters (8,600 ft)	Oct-82	$4.00 (westbound)	FasTrack	N	N(Maintained by California Dept. of Transportation)

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Golden Gate Bridge	CA	San Francisco, California and Marin County, California	6	Suspension, truss arch & truss causeways	8,981 feet (2,737 m)	27-May-37	US$6.00 (southbound) (US$5.00 with FasTrak)	FasTrack	N	Public Owner Private Operator
Richmond-San Rafael Bridge	CA	San Rafael, California and Richmond, California	4	2 Cantilever bridges	8,851.39 meters (29,040 ft)	September 1, 1956	$4.00 (westbound)	FasTrack	N	Maintained by California Dept. of Transportation
San Francisco-Oakland Bay Bridge	CA	San Francisco and Oakland	10	Double-decked Suspension, Truss & Cantilever Bridges and Tunnel	West: 9,260 feet (2,820 m) East: 10,176 feet (3,102 m) Total: 8.4 miles (13.5 km)	November 12, 1936	Cars $4.00 (westbound only)	FasTrack	N	N(Maintained by the California Department of Transportation)
San Mateo-Hayward Bridge	CA	Foster City, California and Hayward, California	6		11,265.41 meters (36,960 ft)	Oct-67	$4.00 (westbound)	FasTrack	N	N (California Department of Transportation)
Florida State Road 922	FL	North Miami, Bay Harbor Islands, and Bal Harbour, Florida			3.6-mile (5.8km) east-west	1951	$1.00 (US)		N	N(Maintained by VMS (Operating as an affilate of Florida Department of Transportation))
Cape Coral Bridge	FL	Fort Myers and Cape Coral, Florida	2	Concrete Girder Bridge	3400 feet	March 14, 1964	$2 (Westbound traffic only)	Sunpass	N	N (Lee County Department of Transportation)
Card Sound Bridge	FL	Miami-Dade County and northern Monroe County			2,800-foot (850 m)	25-Jan-28	$1.00 (US)		N	N (Lee County Department of Transportation)
Florida State Road 913	FL	Southwest Road and the Rickenbacker Causeway crossing the Intracoastal Waterway and Virginia Key	6		4.2 mi(6.8 km)		$1.25(southbound automobiles), $1(for drivers with Sunpass)	Sunpass	N	N (Florida Department of Transportation)

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Garcon Point Bridge	FL	U.S. Route 90 and Interstate 10 west of Milton, Florida to U.S. Route 98 east of Gulf Breeze, Florida	2		3.5-mile	1999	$3.50	cash	N	The Santa Rosa Bay Bridge Authority entered into a lease-purchase agreement with the Department, whereby the Department maintains and operates the bridge and remits all tolls collected.
Mid-Bay Bridge (Choctawhatchee Bay)	FL	State Road 20 in Niceville to U.S. Highway 98 in Destin	2		3.6 mi	1994	$2.50	cash	N	Mid-Bay Bridge Authority Okaloosa County, Florida
Midpoint Memorial Bridge	FL	Fort Myers and Cape Coral, Florida	4	Concrete Girder Bridge	1.25 miles	19-Oct-97	$2 (Westbound traffic only)	Sunpass and Leeway	N	N (Lee County Department of Transportation)
Pinellas Bayway	FL	South end: Fort DeSoto Park North end: SR 682 in Tierra Verde	4 - Northern half 2 - Southern half		4.82 mi (7.76 km)	21-Dec-62	$50 annually	Sunpass	N	N (Florida Department of Transportation)
Rickenbacker Causeway	FL	Miami, Florida to Key Biscayne	6			1947	$1.50		N	N (Florida Department of Transportation)
Sanibel Causeway	FL	Sanibel, Florida	2	Concrete Girder Bridge	3 Miles	May 26, 1963	$6 (Westbound traffic only)		N	N (Lee County Department of Transportation)
Sunshine Skyway Bridge	FL	south of St. Petersburg and north of Terra Ceia, Florida	4	continuous pre-stressed concrete cable-stayed bridge	8851.392 meters (5.5 miles)	20-Apr-87	$1 for passenger cars or $0.75 with SunPass	Sunpass	N	N (Florida Department of Transportation)

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Treasure Island Causeway	FL	Treasure Island and St. Petersburg in Pinellas County, Florida					$1.00 toll (westbound travelers had no tolls charged)		N	Maintained by the Treasure Island Development Authority
Venetian Causeway	FL	Miami and Miami Beach, Florida			2/5 mile (600 meters)	1926				N (Miami-Dade County Public Works department)
Chicago Skyway	IL	West end: I-90 / I-94 in Chicago and East end: I-90 at Indiana state line	6		7.8 mi (12.55km)	Apr-58	$3.00 for passenger cars and other two axle vehicles, with higher rates for vehicles with multiple axles	E-Zpass	N	Y (Skyway Concession Company (SCC), a joint-venture between the Australian Macquarie Infrastructure Group and Spanish Cintra Concesiones de Infraestructuras de Transporte S.A)
Fort Madison Toll Bridge	IL	Fort Madison, Iowa and Niota, Illinois	2	swinging truss bridge		26-Jul-27	motorcycles 50 cents, automobiles and pick-up trucks $1.00, trucks larger than a pick-up truck are $2.00 per axle, not including the first axle, buses and RVs are $4.00, add $1.00 additional to any fee if towing a trailer, bicycles are free and pedestrians are prohibited from walking on the road or rail decks	cash	N	BNSF Railway
Frank E. Bauer Bridge	IL	Rockford, IL,	4	Post-tensioned concrete girder	302.4 metres	1993	US$0.50 each way	cash	N	N (Winnebago County, IL)

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Bellevue Bridge	IA	Mills County, Iowa and Sarpy County, Nebraska at Bellevue, Nebraska	2	truss bridge	20 feet wide	1950	$1 tolls for cars		N	
Fort Madison Toll Bridge	IA	Fort Madison, Iowa and Niota, Illinois	2	swinging truss bridge bridge		26-Jul-27	motorcycles 50 cents, automobiles and pick-up trucks $1.00, trucks larger than a pick-up truck are $2.00 per axle, not including the first axle, buses and RVs are $4.00, add $1.00 additional to any fee if towing a trailer, bicycles are free and pedestrians are prohibited from walking on the road or rail decks	cash	N	N (BNSF Railway)
Plattsmouth Bridge	IA	Cass County, Nebraska and Mills County, Iowa via U.S. Route 34		truss bridge		1929			N	N (Plattsmouth, Nebraska)
Crescent City Connection	LA	New Orleans, Louisiana	8	Twin steel truss cantilever bridges	13,428 ft (4,093 m)	April 1958 (eastbound)	Cars: $1.00 (Eastbank bound)	cash	N	N (LaDOTD, Crescent City Connection Division)
Lake Pontchartrain Causeway	LA	Metairie, Louisiana and Mandeville, Louisiana	4	Low-level trestle with mid-span bascule		August 30, 1956 (southbound) May 10, 1969 (northbound)	$3.00 (southbound)		N	N (Greater New Orleans Expressway Commission)

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Chesapeake Bay Bridge	MD	Anne Arundel County, Maryland and Queen Anne's County, Maryland	5	twin steel cantilever bridge (eastbound), arch bridge (westbound) and suspension bridge	22,790 ft or 4.914 mi (6,946 m)	July 30, 1952 (eastbound) June 28, 1973 (westbound)	$2.50 (eastbound)	E-Zpass	N	N (Maryland Transportation Authority)
Francis Scott Key Bridge (Baltimore)	MD	Patapsco River	4	continuous truss arch bridge with suspended plate girder deck	1,200 feet (366 m)	March 23, 1977	$2.00	E-Zpass	N	N (Maryland Transportation Authority)
Governor Harry W. Nice Memorial Bridge	MD	Dahlgren, Virginia and Newburg, Maryland	2	Continuous truss bridge	800 ft (240 m)	Dec-40	$3.00 (southbound) per two-axle vehicle	E-Zpass	N	N (Maryland Transportation Authority)
Millard E. Tydings Memorial Bridge	MD	Havre de Grace, Maryland and Perryville, Maryland	6	Steel Truss - Deck	1,542.6 metres (5,061 ft)	1963	$5.00 (northbound)	E-Zpass	N	N (Maryland Transportation Authority)
Thomas J. Hatem Memorial Bridge	MD	Havre de Grace, MD and Perryville, MD	4	Steel Truss - Thru	2,361.9 metres (7,749 ft)	28-Aug-40	$5.00 (eastbound)	E-Zpass	N	N (Maryland Transportation Authority)
Ambassador Bridge	MI	Detroit, Michigan and Windsor, Ontario	4	n Suspension bridge	7,500 feet (2,286 m)	November 11, 1929	4.00 (USD and CAD)		Y	N (Detroit International Bridge Company and Canadian Transit Company)
Blue Water Bridge	MI	Port Huron, Michigan and Point Edward, Ontario	6	Cantilever truss (westbound) Continuous tied arch (eastbound)	6,178 feet (1,883 m) (westbound) 6,109 feet (1,862 m) (eastbound)	October 10, 1938 (westbound) July 22, 1997 (eastbound)	Cars: USD$2.75 (westbound)) USD$1.50 (eastbound)	Maintained by Blue Water Bridge Authority	Y	N (MDOT and Blue Water Bridge Authority)
Grosse Ile Toll Bridge	MI	Grosse Ile and Wayne County, MI		Swing bridge		November 27, 1913	$1.50 (for cash), $1.20 (for GIBC token)	cash	N	Maintained by Grosse Ile Bridge Company

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Mackinac Bridge	MI	Mackinaw City and St. Ignace, Michigan	4	Suspension bridge	26,372 feet (8,038 m)	November 1, 1957	$1.50 per axle for passenger vehicles ($3.00 per car). $3.50 per axle for motor homes. $3.50 per axle for commercial vehicles		N	N(Mackinac Bridge Authority)
Sault Ste. Marie International Bridge	MI	Sault Ste. Marie, Michigan-Sault Ste. Marie, Ontario	2	truss arch bridge	2.8 miles	1962	$2.00 (USD), $2.00 (CAD), $1.00 (USD) for bicycles		N	Maintained by International bridge authority of Michigan
Wayne County Bridge	MI	Wayne County, Michigan, Grosse Ile and Trenton		Swing bridge		September 1931			N	N (Wayne County Road Commission)
Basilone Bridge	NJ	Edison Township on the north with New Brunswick on the south				1951			N	
Bayonne Bridge	NJ	Staten Island, New York and Bayonne, New Jersey	4	Steel Arch bridge	5,780 feet (1,761.74 m)	November 15, 1931	$8.00 (southbound) ($6.00 off-peak	E-Zpass	N	N(Port Authority of New York and New Jersey)
Beesley's Point Bridge	NJ	Upper Township, in Cape May County to Somers Point in Atlantic County							N	N(Beesley's Point Bridge Commission), The bridge was purchased in 2008 by Cape May County
Benjamin Franklin Bridge	NJ	Philadelphia (Center City), Pennsylvania to Camden, New Jersey	7	steel suspension bridge	2,917.86 meters (9,573 feet)	1-Jul-26	Cars $4.00 (westbound into PA)	E-Zpass	N	N(Delaware River Port Authority of Pennsylvania and New Jersey)
Betsy Ross Bridge	NJ	Philadelphia, PA and Pennsauken Township, NJ	6	Steel Continuous truss bridge	8,485 feet (2,586 meters)	30-Apr-76	$4.00 (westbound)	E-Zpass	N	N(Delaware River Port Authority of Pennsylvania and New Jersey)

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Burlington-Bristol Bridge	NJ	Bristol Township, Pennsylvania and Burlington, New Jersey	2	steel vertical lift bridge	2,301 feet (701.3 m)	2-May-31	$2.00 (westbound)	E-Zpass	N	N(Burlington County Bridge Commission)
Commodore Barry Bridge	NJ	Chester, Pennsylvania to Bridgeport, New Jersey	5	steel cantilever bridge	4,240.38 meters (13,912 feet)	February 1, 1974	$4.00 (westbound)	E-Zpass	N	N(Delaware River Port Authority of Pennsylvania and New Jersey)
Delaware Memorial Bridge	NJ	New Castle, Delaware and Deepwater, New Jersey	8	steel suspension bridge	10,765 feet (3,281 m) (eastbound) 10,796 feet (3,291 m) (westbound)	August 16, 1951 (eastbound) September 12, 1968 (westbound)	Cars $3.00 (westbound)	E-Zpass	N	N(Delaware River and Bay Authority)
Delaware River Joint Toll Bridge Commission	NJ	Pennsylvania and New Jersey					75-cent cash auto toll (60 cents for E-ZPass, and 45 cents for frequent E-ZPass commuter users).Truck tolls range from $5 to $22.75, depending on axle type, time of travel and whether E-ZPass is used	cash	N	N (bistate public agency)
Delaware River-Turnpike Toll Bridge	NJ	Bristol Township, Pennsylvania and Burlington Township, New Jersey	4	steel arch-shaped suspended-deck truss bridge	2,003 m (6,572 ft)	May 25, 1956	$1.50, both directions	E-Zpass	N	N(Pennsylvania Turnpike Commission and New Jersey Turnpike Authority)
Delaware Water Gap Toll Bridge	NJ	Delaware Water Gap, Pennsylvania and Hardwick Township, NJ	4	Steel cable beam bridge	2,465 ft (751 m)	December 16, 1953	75¢ (automobiles)	cash	N	Maintained by Delaware River Joint Toll Bridge Commission

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Dingman's Ferry Bridge	NJ	Delaware Township, Pike County, Pennsylvania and Sandyston Township, New Jersey	2	truss bridge	530 ft	Nov-00	$1.00, both directions.	cash	N	Dingmans Choice and Delaware Bridge Company
Driscoll Bridge	NJ	Middlesex County communities of Woodbridge Township on the north with Sayreville on the south.	seven southbound lanes. eight northbound lanes			3-May-06	$1.00 on southbound motorists	cash	N	
Easton-Phillipsburg Toll Bridge	NJ	Easton, PA and Phillipsburg, NJ	4		1,020 feet	January 14, 1938	$0.75 (westbound only)	E-Zpass	N	N(Delaware River Joint Toll Bridge Commission)
George Washington Bridge	NJ	Fort Lee, New Jersey and Manhattan in New York City	14	Double-decked Suspension bridge	4,760 ft (1,450 m)	October 24, 1931 (upper level) August 29, 1962 (lower level)	Cars $8.00 ($8 peak / $6 off-peak with E-ZPass) $2 when carpooling w/ 3 people or more w/ EZ-Pass (cars only) (eastbound only)		N	N(Port Authority of New York and New Jersey)
Goethals Bridge	NJ	Elizabeth, New Jersey and Howland Hook, Staten Island, New York City	4	Cantilever bridge	2,164.08 m (7,100 ft)	29-Jun-28	$8.00 (eastbound) ($6.00 off-peak)	E-Zpass	N	N(Port Authority of New York and New Jersey)
Interstate 78 Toll Bridge	NJ	Williams, PA and Phillipsburg, NJ	6	Twin girder bridge	372 meters (1,222 feet)	21-Nov-89	$0.75 (westbound only)	E-Zpass	N	N(Delaware River Joint Toll Bridge Commission)
Milford-Montague Toll Bridge	NJ	Milford Township, Pennsylvania and Montague Township, NJ	2	Steel deck truss bridge	1,150 ft	30-Dec-53	75¢ (automobiles)	cash	N	N(Delaware River Joint Toll Bridge Commission)

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
New Hope-Lambertville Toll Bridge	NJ	Delaware Township, New Jersey and Solebury Township, Pennsylvania	4	Girder	1,682 feet (513 m)	July 22, 1971	$0.75 ($0.60 with E-ZPass, entering PA Only Southbound)	E-Zpass	N	N(Delaware River Joint Toll Bridge Commission)
Newark Bay Bridge	NJ	Newark, NJ and Bayonne, NJ	4	Three-span continuous arch bridge	9,560 feet	April 4, 1956	$0.80 - from NJ Turnpike exit 14 to 14A (E-ZPass)	E-Zpass	N	N(New Jersey Turnpike Authority)
Outerbridge Crossing	NJ	Perth Amboy, N J and SW, NY	4	Steel Cantilever bridge	10,140 feet (3,093 m)	June 29, 1928	$8.00 (eastbound) ($6.00 off-peak E-ZPass)	E-Zpass	N	N(Port Authority of New York and New Jersey)
Portland-Columbia Toll Bridge	NJ	Portland, Pennsylvania and Columbia, New Jersey	2	Ten-span steel girder	1,309 ft (399 m)	December 1, 1953	75¢ (automobiles)	cash	N	N(Delaware River Joint Toll Bridge Commission)
Tacony-Palmyra Bridge	NJ	Philadelphia (Tacony), Pennsylvania and Palmyra, New Jersey	3	steel arch bridge with bascule	3,569 feet (1115.3 meters)	14-Aug-29	$2.00 (westbound) (E-ZPass)	E-Zpass	N	N(Burlington County Bridge Commission)
Trenton-Morrisville Toll Bridge	NJ	Morrisville, Pennsylvania and Trenton, New Jersey	5		403.56 meters (1,324 feet)	1952	$0.75 (westbound) (E-ZPass)	E-Zpass	N	N(Delaware River Joint Toll Bridge Commission)
Walt Whitman Bridge	NJ	Philadelphia, Pennsylvania to Gloucester City, New Jersey	7	steel suspension bridge	3,651.81 meters (11,981 feet)	16-May-57	$4.00 (westbound) (E-ZPass)	E-Zpass	N	N(Delaware River Port Authority of Pennsylvania and New Jersey)
Bear Mountain Bridge	NY	NW of Peekskill, NY	2	Suspension bridge	1,641 feet (497 m)	November 27, 1924	Cars $1.00 (eastbound)		N	N(New York State Bridge Authority)
Castleton Bridge	NY	Castleton-on-Hudson, New York					$0.50 toll each way		N	N(New York State Bridge Authority)
Kingston-Rhinecliff Bridge	NY	Kingston, NY, Rhinecliff, NY	2	Continuous Under-deck Truss Bridge	7,793 ft (2375 m)	February 2, 1957	US$1.00		N	N(New York State Bridge Authority)
Mid-Hudson Bridge	NY	Highland, NY, Poughkeepsie, NY	3	Suspension bridge	914.4 meters (3,000 feet)	25-Aug-30	$1 passenger cars, eastbound via cash or (E-ZPass)	cash or E-Zpass	N	N(New York State Bridge Authority)

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Lewiston-Queenston Bridge	NY	NY	5	Arch Bridge	1600 ft	1962	$ 3.25		Y	NY State
New York State Bridge Authority	NY	City of Hudson and the Village of Catskill				31-Mar-32	$1.00 for eastbound traffic	E-Zpass	N	N(public benefit corporation in New York State)
Newburgh-Beacon Bridge	NY	Newburgh, New York and Beacon, New York	6	Twin span Cantilever bridges	(2,394 meters (7,855 feet)	1963 (westbound) 1, 1980 (eastbound)	Cars $1.00 (eastbound)		N	N(New York State Bridge Authority)
Peace Bridge	NY	Fort Erie, Ontario and Buffalo, New York		through truss and arch bridge	5,800 feet (1,768 m)	June 1, 1927	$3.00 ($2.70 with E-ZPass)	E-Zpass	Y	N(Buffalo and Fort Erie Public Bridge Authority (Peace Bridge Authority))
Rip Van Winkle Bridge	NY	Hudson, New York and Catskill, New York		Cantilever and Truss	5,040 ft.	1935	$1.00		N	N(New York State Bridge Authority)
Rainbow Bridge	NY	NY-Ontario	4	Arch Bridge		1941	$3.25	E-Zpass	Y	
Seaway Int Bridge	NY	NY-Ontario		Truss Bridge	1652 m	1962	$ 3.25		Y	NY State
Tappan Zee Bridge	NY	South Nyack and Tarrytown, New York	7	Cantilever bridge	16,013 feet (4,881 m)	December 15, 1955	(eastbound/southbound only) $4.50 (cash) $4.28 (E-ZPass)	cash or E-Zpass	N	N(New York State Thruway Authority)
Whirlpool Rapids Bridge	NY	NY and Niagara Falls	2	Arch Bridge	167.6 m	1897	$3.25	NEXUS	Y	NY State
Bridge of the Gods (modern structure)	OR	Cascade Locks, OR		Cantilever through truss	1,856 ft (565 m)	1926			N	Maintained by Port of Cascade Locks
Hood River Bridge	OR	Hood River, OR and White Salmon, WA		Through-truss with a vertical lift	4,755 ft	9-Dec-24	$0.75 per axle for vehicles, and $0.50 for motorcycles		N	Maintained by the Port of the Hood River
The Dalles Bridge	OR	The Dalles, Oregon		cantilever truss	3,339 ft	December 18, 1953			N	
Benjamin Franklin Bridge	PA	Philadelphia (Center City), PA to Camden, NJ	7	steel suspension bridge	2,917.86 meters (9,573 feet)	1-Jul-26	Cars $4.00 (westbound into PA) (E-ZPass)	E-Zpass	N	N(Delaware River Port Authority of Pennsylvania and New Jersey)
Betsy Ross Bridge	PA	Philadelphia, PA and NJ	6	Steel Continuous truss bridge	8,485 feet (2,586 meters)	30-Apr-76	$4.00 (westbound) (E-ZPass)	E-Zpass	N	Delaware River Port Authority PA and NJ

Table 1: Contd.

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Burlington-Bristol Bridge	PA	Bristol Township, Pennsylvania and Burlington, New Jersey	2	steel vertical lift bridge	2,301 feet (701.3 m)	May 2, 1931	$2.00 (westbound) (E-ZPass)	E-Zpass	N	N(Burlington County Bridge Commission). It is a public agency commission.
Commodore Barry Bridge	PA	Chester, Pennsylvania to Bridgeport, New Jersey	5	steel cantilever bridge	4,240.38 meters (13,912 feet)	1-Feb-74	$4.00 (westbound) (E-ZPass)	E-Zpass	N	N(Delaware River Port Authority of Pennsylvania and New Jersey)
Delaware River Joint Toll Bridge Commission	PA	Pennsylvania and New Jersey					75-cent cash auto toll (60 cents for E-ZPass, and 45 cents for frequent E-ZPass commuter users).Truck tolls range from $5 to $22.75, depending on axle type, time of travel and whether E-ZPass is used	E-Zpass	N	It is a bistate, public agency
Delaware River-Turnpike Toll Bridge	PA	Bristol Township, Pennsylvania and Burlington Township, New Jersey	4	steel arch-shaped suspended-deck truss bridge	2,003 m (6,572 ft)	May 25, 1956	$1.50, both directions (E-ZPass)	E-Zpass	N	N(Maintained by the Pennsylvania Turnpike Commission and New Jersey Turnpike Authority)
Delaware Water Gap Toll Bridge	PA	Delaware Water Gap, Pennsylvania and Hardwick Township, New Jersey	4	Steel cable beam bridge	2,465 ft (751 m)	16-Dec-53	75¢ (automobiles)	cash	N	Maintained by Delaware River Joint Toll Bridge Commission
Dingman's Ferry Bridge	PA	Delaware Township, Pike County, PA and Sandyston Township, NJ	2	truss bridge	530 ft	November 1900	$1.00, both directions.		N	Maintained by the Dingmans Choice and Delaware Bridge Company

Table 1: Contd.

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Easton-Phillipsburg Toll Bridge	PA	Easton, PA and Phillipsburg, NJ	4		1,020 feet	14-Jan-38	$0.75 (westbound only) E-Zpass	E-Zpass	N	N(Maintained by the Delaware River Joint Toll Bridge Commission)
Interstate 78 Toll Bridge	PA	Williams, PA and Phillipsburg, NJ	6	Twin girder bridge	372 meters (1,222 feet)	November 21, 1989	$0.75 (westbound only) E-Zpass	E-Zpass	N	N(Maintained by the Delaware River Joint Toll Bridge Commission)
Milford-Montague Toll Bridge	PA	Milford Township, Pennsylvania and Montague Township, New Jersey	2	Steel deck truss bridge	1,150 ft	30-Dec-53	75¢ (automobiles)		N	N(Maintained by the Delaware River Joint Toll Bridge Commission which is a bi-state public agency)
New Hope-Lambertville Toll Bridge	PA	Delaware Township, New Jersey and Solebury Township, Pennsylvania	4	Girder	1,682 feet (513 m)	July 22, 1971	$0.75 ($0.60 with E-ZPass, entering PA Only Southbound)	E-Zpass	N	N(Maintained by the Delaware River Joint Toll Bridge Commission which is a bi-state public agency)
Portland-Columbia Toll Bridge	PA	Portland, Pennsylvania and Columbia, New Jersey	2	Ten-span steel girder	1,309 ft (399 m)	1-Dec-53	75¢ (automobiles)	cash	N	N(Maintained by the Delaware River Joint Toll Bridge Commission which is a bi-state public agency)
Susquehanna River Bridge	PA	Harrisburg, Pennsylvania	4	steel girder bridge	4,526 feet	old bridge: 1950; new bridge: 2007	Fares dictated by Pennsylvania Turnpike (E-ZPass)	E-Zpass	N	N(Maintained by the Pennsylvania Turnpike Commission)
Tacony-Palmyra Bridge	PA	Philadelphia (Tacony), Pennsylvania and Palmyra, New Jersey	3	steel arch bridge with bascule	3,569 feet (1115.3 meters)	August 14, 1929	$2.00 (westbound) (E-ZPass)	E-Zpass	N	N(Maintained by the Burlington County Bridge Commission which is a public agency)

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Trenton-Morrisville Toll Bridge	PA	Morrisville, Pennsylvania and Trenton, New Jersey	5		403.56 meters (1,324 feet)	1952	$0.75 (westbound) (E-ZPass)	E-Zpass	N	N(Maintained by the Delaware River Joint Toll Bridge Commission which is a bi-state public agency)
Walt Whitman Bridge	PA	Philadelphia, Pennsylvania to Gloucester City, New Jersey	7	steel suspension bridge	3,651.81 meters (11,981 feet)	16-May-57	$4.00 (westbound) (E-ZPass)	E-Zpass	N	N(Maintained by the Delaware River Port Authority of Pennsylvania and New Jersey)
Colombia-Solidarity International Bridge	TX	Laredo, Texas Colombia, Nuevo Leon		Box Girder Bridge	1216 ft	1992	Northbound / Southbound Non-Commercial Vehicles $3.00 / $2.25 Commercial Vehicles $2.75 per Axle		Y	N(Maintained by the City of Laredo Secretariat of Communications and Transportation)
Gateway to the Americas International Bridge	TX	Laredo, Texas – Nuevo Laredo, Tamaulipas	4	Box Girder Bridge	1050 ft (309 m)	1954	Southbound / Northbound Pedestrians $0.75 / $0.30 Non-Commercial Vehicles $3.00 / $2.25 Commercial Vehicles $2.75 per Axle		Y	N(Maintained by the City of Laredo Secretariat of Communications and Transportation)
Juarez-Lincoln International Bridge	TX	Laredo, Texas –' Nuevo Laredo, Tamaulipas	8	Box Girder Bridge	1008 ft (481 m)	1976	Southbound / Northbound Non-Commercial Vehicles $3.00 / $2.25 Commercial Vehicles $2.75 per Axle		Y	N(Maintained by the City of Laredo Secretariat of Communications and Transportation)

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Lewisville Lake Toll Bridge	TX	Swisher Road in Lake Dallas to Eldorado Parkway in Lakewood Village.	4	Ach Bridge	13 mi	expected to be completed in the Third quarter of 2009	$1.00 for Tolltag customers and $1.25 for non-Tolltag drivers		N	The North Texas Tollway Authority (NTTA) is working cooperatively with Denton County to plan and design a toll bridge across the northwestern arm of Lewisville Lake.
Mountain Creek Lake Bridge	TX	Grand Prairie, Texas	2	Stringer/Multi-beam or Girder	7,425 ft (2263.1 m)	April 1979	$0.25 per axle on vehicle		N	N(Maintained by the North Texas Tollway Authority)
Sam Houston Ship Channel Bridge	TX	Harris County, Texas	4			May-82			N	Maintained by Harris County Toll Road Authority system
World Trade International Bridge	TX	Laredo, Texas – Nuevo Laredo, Tamaulipas	8	Box Girder Bridge	977 ft (343 m)	2000	Commercial Vehicles $2.75 per Axle		Y	N(Maintained by the City of Laredo Secretariat of Communication and Transportation)
Chesapeake Bay Bridge-Tunnel	VA	Virginia Beach, Virginia to Cape Charles, Virginia	4	Composite: Low-level Trestle, Single-tube Tunnels, Man made islands, Truss bridges, High-level Trestle	17.6 miles (28 km)	April 15, 1964 (northbound) April 19, 1999 (southbound)	Cars $12 (each direction, round trip discount available) Smart Tag/E-Zpass	E-Zpass	N	N(Maintained by the Chesapeake Bay Bridge and Tunnel Commission which is a political subdivision of the Commonwealth of Virginia)
George P. Coleman Memorial Bridge	VA	Gloucester Point and Yorktown, Virginia	4	Swing bridge (two swinging spans)	3,750 feet (1,140 m)	May 7, 1952	$2.00 (northbound) Smart Tag/E-Zpass	E-Zpass	N	N(Maintained by the Virginia Department of Transportation)
Governor Harry W. Nice Memorial Bridge	VA	Dahlgren, Virginia and Newburg, Maryland	2	Continuous truss bridge	800 ft (240 m)	Dec-40	$3.00 (southbound) per two-axle vehicle with E-ZPass accepted	E-Zpass	N	N(Maintained by the Maryland Transportation Authority)

Table 1: Contd.

Bridge Name	State	Location	Number of Lanes	Design Type	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body) PPP (Y - Private body)
Jordan Bridge	VA	State Route 337 over the southern branch of the Elizabeth River in the City of Chesapeake in South Hampton Roads in southeastern Virginia.	2	toll bridge		24-Aug-28	50 cents for motorcycles, 75 cents for two axle vehicles, $1.00 for three axles and $1.25 for four axles	cash	N	This bridge was permanently closed on November 8, 2008. A replacement, to be built with 100% **private funds** was approved by Chesapeake City Council on January 27, 2009
Robert E. Lee Memorial Bridge	VA	U.S. Route 1 and U.S. Route 301 across the James River at the fall line	4	toll bridge	3,760 ft	1934	Toll free		N	N(Owned by Virginia Department of Transportation)
Bridge of the Gods (modern structure)	WA	Cascade Locks, Oregon	2	Cantilever through truss	1,856 ft (565 m)	1926	$0.75	cash/Toll ticket/creditcard	N	Maintained by the Bridge of the Gods (modern structure)
Hood River Bridge	WA	Columbia River between Hood River, Oregon and White Salmon, Washington		Through-truss with a vertical lift	4,755 ft	9-Dec-24	$0.75 per axle for vehicles, and $0.50 for motorcycles		N	Currently the bridge is operated as a toll bridge by the Port of Hood River.

Tunnels and Highways

Table 2: Tunnels and Highways

Bridge Name	State	Location	Number of Lanes	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body), PPP (Y - Private body)
91 Express Lanes	CA	Costa Mesa Freeway (State Route 55) interchange in Anaheim to the Riverside County line	4 lanes	10 miles	1995	$4.20/$10.00	C/F	N	N
California State Route 73	CA	San Joaquin Hills in Orange County, California		15 miles	1996	$.50/$1.25	C/F	N	Kiewit Corporation(Y)
Eastern Toll Road (California)	CA	Orange County, California	4 to 6 lanes	24 miles	1998		Credit Card	N	N (Transportation Corridor Agencies)
Foothill Toll Road	CA	Orange County, California		23 miles	1993			N	N (Owned by the State of California)
E-470	CO	Eastern portion of the Denver-Aurora Metropolitan Area		46 miles	1991	$.18 per mile	C/F	N	N (E-470 Public Highway Authority)
Northwest Parkway	CO	Broomfield, Colorado	4 lanes	11 miles	2003	$2.50	C/F	N	Y
Connecticut Route 2A	CT	Norwich, Conn. To Preston, Conn.	2 lanes	9.91 miles	1967	$0.15		N	N
Connecticut Turnpike	CT	Byram, Conn. to South Killingly, Conn.	6 lanes	128.47 miles	1958			N	N
Merritt Parkway	CT	Fairfield County, Connecticut	4 lanes	37.27 miles	1938			N	Local
Wilbur Cross Parkway	CT	Milford, Conn. to Meriden, Conn.	4 lanes	29.46 miles	1941			N	N
Delaware Route	DE	MD-Delaware State to DE	4 to 6 lanes	110 miles	1978	$2/$4		N	N

Table 2: Contd.

Bridge Name	State	Location	Number of Lanes	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body), PPP (Y - Private body)
Delaware Turnpike	DE	Maryland State Line and Newport, Delaware and Newport and the Farnhurst interchage		11.2 miles	1963			N	N
Alligator Alley	FL	East Naples, Fl. To Davie, Fl.		84.28 miles				N	N
Florida State Road 112	FL	Miami International Airport in Miami to Miami Beach						N	N
Florida State Road 408	FL	Bithlo, Fl. To Ocoee, Fl.		22.13 miles				N	N
Florida State Road 414	FL	Maitland, Fl. To Clarcona, FL.		6.53 miles				N	N
Florida State Road 570	FL	Polk City, Fl. To Plant City, Fl.		25 miles				N	PPP between the Florida Department of Transportation—Florida's Turnpike Enterprise, USF Polytechnic , the Polk County Board of County Commissioners and The Williams Company
Florida State Road 589	FL	Crystal River, Fl to Tampa, Fl.		53.65 miles		$3		N	N
Florida State Road 836	FL	Miami, Fl. To Sweetwater, Fl.	6 lanes	16 miles				N	N
Florida State Road 874	FL	Glenvar Heights, Fl. To Richmond Heights, Fl.		6.4 miles				N	N
Florida State Road 924	FL	Hialeah, Fl. To North Miami, Fl.		8.49 miles				N	N

Table 2: Contd.

Bridge Name	State	Location	Number of Lanes	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body), PPP (Y - Private body)
Florida's Turnpike	FL	Golden Glades Interchange to Wildwood, Fl.		264.96 miles				N	N
Lee Roy Selmon Crosstown Expressway	FL	Brandon, Fl. To Tampa, Fl.		15 miles				N	N
Osceola Parkway	FL	Between Florida's Turnpike with the Walt Disney World Resort		12 miles				N	N
Pinellas Bayway	FL	Fort DeSoto Park to Tierra Verde, Fl.		4.82 miles				N	N
Rickenbacker Causeway	FL	Miami, Florida, USA to the barrier islands of Virginia Key and Key Biscayne	6 lanes	3.9 miles				N	N
Sanibel Causeway	FL	Sanibel Island to the Florida mainland in South Fort Myers		3 miles		$6		N	N
Sawgrass Expressway	FL	Deerfield Beach, Fl. To Weston, Fl.		23 miles				N	N
Venetian Causeway	FL	Crosses Biscayne Bay in Miami-Dade County, Florida				$1.50		N	N
Georgia State Route 400	GA	Buckhead, Ga. To Dahlonega, Ga.		53.75 miles				N	N
Chicago Skyway	IL	Interstate 90 at the Dan Ryan Expressway on the west end, and the Indiana Toll Road		7.8 miles		$3		N	N
Jane Addams Memorial Tollway	IL	South Beloit, Il to Chicago, Il	4-6 lanes	79 miles		$.40-1.60		N	N

Table 2: Contd.

Bridge Name	State	Location	Number of Lanes	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body), PPP (Y - Private body)
Ronald Reagan Memorial Tollway	IL	Hillside, Il to Sterling, Il		96 miles				N	N
Tri-State Tollway	IL	Zion, Il to Thornton, Il		78 miles				N	N
Veterans Memorial Tollway	IL	Itasca, Il to New Lenox, Il		32.5 miles				N	N
Indiana Toll Road	IN	Ohio state line to Illinois state line		156.9 miles		$4.15		N	Y(The Indiana Toll Road Concession Company (ITRCC), is the subsidiary of the Macquarie Infrastructure Group and Cintra Concesiones de Infraestructuras de Transporte joint-venture that operates and maintains the Indiana East-West Toll Road
Kansas Turnpike	KS	Kansas City, MO to Braman, OK		236 miles		$9.25		N	N
Crescent City Connection	LA	Over the Mississippi River in New Orleans, Louisiana	8 lanes	13,428 feet (4,093 m)		$1		N	N
Lake Pontchartrain Causeway	LA	Metairie, Louisiana and Mandeville, Louisiana	4 lanes	23.87 miles		$3		N	N
Maine Turnpike	ME	Kittery, ME to Augusta, ME		109 miles		$1 - $1.75		N	N
Harbor Tunnel Thruway	MD	Baltimore, MD to Elkridge, MD		14.87 miles		$2		N	N

Table 2: Contd.

Bridge Name	State	Location	Number of Lanes	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body), PPP (Y - Private body)
John F. Kennedy Memorial Highway	MD	Baltimore City line to the Delaware State line	8 lanes	50 miles		$5		N	N
Massachusetts Turnpike	MA	West Stockbridge, MA to Boston, MA		138 miles		$3.50-$5.10		N	N
Sumner Tunnel	MA	Logan International Airport to downtown Boston, Massachusetts		5,653 feet (1,723 m)		$3.50-$5.25	C/F	N	N
Ted Williams Tunnel	MA	South Boston, Massachusetts to Logan International Airport		8,448 feet (2,575 m)		$3/$4.50	C/F	N	N
Interstate 394	MN	Minneapolis, MN to Minnetonka, MN		9.5 miles		$1-$4	C/F	N	N
Interstate 95 in New Hampshire	NH	Salisbury, MA to Kittery, ME		16.08 miles		$1.50	C	N	N
Everett Turnpike	NH	Massachusetts border at Nashua north to Concord		44 miles	1955	$.35/$1.71	C/F	N	N
Spaulding Turnpike	NH	Interstate 95 in Portsmouth northwest to Milton	2-4 lanes	33.2 miles	1956	$0.75	C	N	N
Atlantic City Expressway	NJ	Washington Twp, NJ to Atlantic City, NJ		44 miles	1964	$2/$.50	C/F	N	N
Garden State Parkway	NJ	Montvale, NJ to Cape May, NJ		172.40 mi	1946	$.25-$.75	C/F	N	N
New Jersey Turnpike	NJ	Pennsville, NJ to Fort Lee, NJ	10-14 lanes	122.40 mi	1951	$4.85-$6.45	C/F	N	N
New England Thruway	NY	Bruckner Expy in the Bronx, NY to Connecticut		15 miles	1951	$1.25	C	N	N

Table 2: Contd.

Bridge Name	State	Location	Number of Lanes	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body), PPP (Y - Private body)
New York State Thruway	NY							N	N
Ohio Turnpike	OH	Ohio-Pennsylvania border to Ohio-Indiana border	6 lanes	241.26 miles	1-Oct-55	$10.25	C/F	N	N
Cherokee Turnpike	OK	US 412 from east of Kansas, Oklahoma to east of Chouteau	4 lanes	46 miles	1991	$2.15/ $2.25	C/F	N	N
Chickasaw Turnpike	OK	Sulphur, Oklahoma to just south of Ada, Oklahoma	2 lanes	17.3 miles	1991	55¢ /45¢	C/F	N	N
Cimarron Turnpike	OK	Interstate 35 north of Perry, to Westport, just west of Tulsa		59.2 miles	1975	$2.50/ $2.35	C/F	N	N
Creek Turnpike	OK	Sapulpa, OK to Tulsa, OK		33.22 miles	July 30, 1992	$2.45/ $2.30	C/F	N	N
H. E. Bailey Turnpike	OK	Oklahoma City to Lawton and Wichita Falls, Texas	4 lanes	86.4 miles	23-Apr-64	$4.00/ $3.80	C/F	N	N
Indian Nation Turnpike	OK	Henryetta, OK to Hugo, OK	4 lanes	105.2 miles	1966	$4.75/ $4.50	C/F	N	N
John Kilpatrick Turnpike	OK	Oklahoma City, Oklahoma		25.3 miles	1-Sep-91	$2.00	C/F	N	N
Muskogee Turnpike	OK	Broken Arrow, OK to Webber's Falls, OK		53.1 miles	16-Oct-69	$2.50/ $2.40	C/F	N	
Turner Turnpike	OK	Sapulpa, OK to Oklahoma City, OK		86.0 miles	16-May-53	$3.50/ $3.35	C/F	N	N
Will Rogers Turnpike	OK	Tulsa, OK to the Missouri state line		88.5 miles	28-Jun-57	$3.50	C/F	N	N
I-476/Northeast Extension	PA	Clarks Summit, PA to Chester, PA	4 lanes	132.10 mi	1964		C	N	N
Pennsylvania Route 60	PA	Sharon, PA to Pittsburgh, PA		74 miles	1956	$0.50 - $2.00	C/F	N	N

Table 2: Contd.

Bridge Name	State	Location	Number of Lanes	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body), PPP (Y - Private body)
Pennsylvania Route 66	PA	Kane, PA to New Stanton, PA		139 miles	1927	$1.00		N	N
Pennsylvania Route 576	PA	Pittsburgh International Airport to the historic Steel Valley of the Monongahela River.		6.5 miles		$0.50		N	N
Pennsylvania Turnpike	PA	Delaware River Bridge to Pennsylvania-Ohio state line		359.6 miles	Oct-40		C/F	N	N
Puerto Rico Highway 22	PR	Hatillo, PR to San Juan, PR	4-12 lanes	51 miles	1999			N	N
Puerto Rico Highway 52	PR	San Juan, PR		108 km				N	N
Puerto Rico Highway 53	PR	Fajardo, PR to Salinas, PR					C/F	N	
Interstate 185	SC	Henrydale Drive, SC to Mauldin, SC		17.70 miles	1955	$1.00 per passenger	C/F	N	N
U.S. Route 278	SC	Greenville, South Carolina						N	
183A toll road	TX	Williamson County (Austin, Texas)			2007			N	N
Dallas North Tollway	TX	Dallas, TX to Frisco, TX		22 miles	1968	$0.40 - $1.30	C/F	N	Y
Fort Bend Parkway Toll Road	TX	Sugar Land, TX to Houston, TX		7.5 miles	1988			N	
Hardy Toll Road	TX	Houston, TX	4-6 lanes	21.6 miles	1988	$3.00	C/F	N	
President George Bush Turnpike	TX	Garland, TX to Irving, TX		34 miles	1977	$.70/$1.00	C/F	N	N
Texas State Highway 121	TX	Downtown Fort Worth, Texas to Bonham, Texas		85.56 miles	1939		C/F	N	N

Table 2: Contd.

Bridge Name	State	Location	Number of Lanes	Length	Year of Opening	Toll Charge	Type of Toll Collection (Cash/FasTrack)	International Crossing (Y/N)	OTG/ (N - Public body), PPP (Y - Private body)
Texas State Highway 255	TX	From the Colombia International Bridge northeast to Interstate 35		22.451 miles	2004	$10.00	C	N	N
Texas State Highway Beltway 8	TX	Houston, TX to Pasadena, TX	4-8 lanes	83.13 miles	1969		C	N	Y
Texas State Highway Loop 1	TX	The west side of Austin, TX		25.698 miles	1967		C	N	N
Texas State Highway Loop 49	TX	Around Tyler, TX		5 miles	1986		C	N	N
Westpark Tollway	TX	Houston, TX		20 miles	2004		C/F	N	Y
Chesapeake Expressway	VA	Near Moyock, NC to Chesapeake, Virginia		12.06 miles	2001	$2.00	C/F	N	N
Virginia State Route 195	VA	Richmond, VA		3.39 miles	1976	$.50-$.80	C/F	N	N
Dulles Greenway	VA	Leesburg, VA to Falls Church, VA		12.53 miles	1982	$3.50-$9.60	C/F	N	Y
Dulles Toll Road	VA	Capital Beltway near Falls Church, VA to Dulles Greenway		16.15 miles	1984	$.75/$.50	C/F	N	N
Virginia State Route 895	VA	Bensley, VA to Varina, VA		8.52 miles	1990s		C	N	Y
Virginia State Route 76	VA	Brandermill, VA to Richmond, VA		12 miles	1973		C/F	N	N
West Virginia Turnpike	WV	Beckley, WV to Princeton, WV	4 lanes	88 miles	1986	$1.25/$0.25	C/F	N	N